STUDIES ON MARINE ORNAMENTAL FISHES OF LAKSHADWEEP

THESIS

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UNDER THE FACULTY OF MARINE SCIENCES

By

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CERTIFICATE

This is to certify that this thesis is an authentic record of the research work carried out by Smt. **VIJAYAMMA T.N.** under my supervision and guidance in the Department of Marine Biology, School of Marine Sciences, Cochin University of Science and Technology, in partial fulfilment of the requirements for the degree of Doctor of Philosophy of the Cochin university of Science and Technology, and no part thereof has been presented before for the award of any other degree, diploma or associateship in any university.

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DECLARATION

I, VIJAYAMMA T.N., do hereby declare that the thesis entitled "STUDIES ON MARINE ORNAMENTAL FISHES OF LAKSHADWEEP" is a genuine record of the research work done by me under the guidance of **Dr. C.K.RADHAKRISHNAN**, Senior Lecturer, Department of Marine Biology, Microbiology and Biochemistry, School of Marine Sciences, Cochin University of Science and Technology and has not been previously formed the basis the award of any degree, diploma or associateship in any university.

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VIJAYAMMA T.N.

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PREFACE

The ornamental or aquarium fishes, by their most fascinating colours, have attracted the attention of mankind and in recent years, there is increasing demand for these fishes to maintain them in home aquaria. The development of technology for transporting live ornamental fishes has helped to revolutionize the ornamental fish trade. The world trade for aquarium fishes is estimated to be about 600 million US $ every year. The largest markets for ornamental fishes are the United States, Japan , the Federal Republic of Germany, the United Kingdom and the Netherlands. The demand for aquarium fishes in these major markets is met mainly through imports from developing countries. The major suppliers of coral reef fishes are the Philippines, Singapore, Indonesia, Srilanka, the Caribbean, Kenya, Mauritius and some Red sea countries. Export of coral reef fishes from the South East Asian countries account for nearly 60% of the export trade in aquarium fishes. Export of aquarium fishes from the Maldives began in 1980 and in 1989 almost 54000 marine fishes worth approximately US $ 130000 were exported.

However, the exploitation of ornamental fishes for export from India has not picked up though vast resources of these fishes exist particularly around the Andaman and Lakshadweep Islands. This situation is mainly the result of:

1. nonavailability of information on the distribution and seasonal variation in abundance of these fishes in different environments,

2. nonavailability of information on various aspects of biology of the constituent species to be able to suggest the different species, and their length groups that can be exploited for the purpose,

3. though some information is available on the various species from particular regions, there is no estimate of resource potential of these species to allow exploitation and monitor the same and

4. the areas of abundance of ornamental fishes are mainly restricted to the Andaman and Lakshadweep Islands of which , the lagoons of Lakshadweep islands are very rich in these fishes. These areas being predominantly coralline in nature and most of the ornamental fishes live in these areas , large scale exploitation for export of these fishes is likely to adversely affect their habitat and therefore without adequate knowledge on the environment, exploitation of these fishes cannot be permitted.

In consideration of these, the Marine Export Development Authority of India(MPEDA) investigated the possibilities for development of export trade of ornamental fishes from India (Anon 1986, Tomey 1985 and 1986). On conducting a survey of marine ornamental fishes of Lakshadweep they found that the commercial fish resources of the Lakshadweep coral reefs and island lagoons comprising a large assemblage of species to meet the incoming export orders completely. The potential of the lagoon water fishery is enormous and promising, provided the natural fishing methods available. The MPEDA has therefore recommended a pilot project for transporting ornamental fishes from the Lakshadweep to the mainland for export purpose.

Considering the world wide demand for ornamental fishes and the tremendous export potential of these fishes from India, the Central Marine Fisheries Research Institute has conducted an indicative survey and brought out a preliminary account on the distribution of ornamental fishes in different Lakshadweep islands (Murty *et al.* 1989). The present work on the ornamental fishes was undertaken with a view to provide baseline information on some species of ornamental fishes, such as their seasonal variation in abundance, some aspects of biology and to understand their relationship with the environmental characteristics particularly from Minicoy, so that the required basic information on these fishes will be available.

The thesis is organized into five chapters with separate introduction, materials and methods, results and discussion for individual chapters. References are given towards the end of the last chapter.

CONTENTS

CHAPTER - II

DISTRIBUTION AND ABUNDANCE OF ORNAMENTAL FISHES IN THE MINICOY LAGOON

GENERAL INTRODUCTION

Pl. 1 to 3

Many of the marine ornamental fishes are found in the coastal habitats within the tropics away from the coral reef regions. But there is a predominance of species, these populations are strongly correlated with the presence of coral reefs (Goldman and Talbot, 1976). The major coral reefs in India include the sedimentary fringing reef of Andamans and Nicobar, a largely submerged barrier reef extending from Tuticorin to Jaffna in the Gulf of Mannar and Lakshadweep atolls. Hence the distribution of ornamental fishes in India is restricted mainly to these coral reef areas.

Among these, Lakshadweep remains to be the least studied group of islands in the Indian Ocean for its coral reef resources, especially for the ornamental fishes. Moreover, the comparatively shallow lagoons around the Lakshadweep islands were a major criterion for selecting Lakshadweep for the present study as it is easy to conduct the various observations and studies on the coral reef fishes in the shallow waters.

Lakshadweep group of islands is located in the Arabian sea, west of Kerala between 8^0 and 12^0 N. Lat. and 71^0 and 74^0E Long. The archipelago consists of 12 atolls, 3 reefs and 5 submerged banks. Of the 36 islands covering an area of 32 sq. Km., 10 are inhabited. They are Minicoy, Kalpeni, Androth, Agatti, Kavaratti, Amini, Kadmat, Kiltan, Chelat and Bitra. The uninhabited islands are Viringli, Cheriyam, Tilakkam , Pitti, Suheli cheriyakara, Suheli valiyakara, Pitti(Bird Island), Kalpitti, Bangaram, Tinnakkara, Parali, Perumal Paar and Cheriyapaniyam and Baliyapaniyam reefs (Plate 1). All these islands except Androth have shallow and saucer-shaped lagoons on the west encircled by coral reefs and storm-beaches on the east with steep coral rocky slopes.

The present study was confined mainly to Minicoy (plate 2) and Kalpeni (plate 3). Minicoy is having the second largest lagoon to that of Bitra. The average depth of the Minicoy and Kalpeni lagoon is around 5 ms.

REVIEW OF LITERATURE

Stark (1968) reported the number of species of single reef system reaching 400 in the tropical Atlantic, and 800 in the Indo - Pacific (Goldman and Talbot, 1976).

There is a visible lack of information regarding the distribution and abundance patterns of reef fishes within the large frame work of entire reef system. Distribution patterns of reef fishes have been described at a few pacific locations (Talbot and Goldman 1972, Jones and Chase 1975, Goldman and Talbot 1976, Anderson *et al.* 1981 and Fowler 1990). The first quantitative estimate of fish abundance in the coral reefs in the St. Lucia Marine Reserve, S.Africa was presented by Chater *et al.*(1995). Spatial distribution of chaetodontids in different sites in Moorea Island, French Polynesia has been investigated by

Cadoret *et al.* (1995). The marine fauna of Minicoy atoll has been reported by Nagabhushanam *et al.* (1972) and the distribution and abundance of ornamental fishes in the Lakshadweep lagoon by Murty *et al.*(1989). Jones and Kumaran(1980) have reported a total of 603 species of various fishes from Lakshadweep reefs.

Harmelin - Vivien and Bouchon - Navaro (1983) reported the length - weight relationship of 15 species from Moorea, French Polynesia.

The general description of the feeding biology of reef fishes have been provided by Davis and Birdsong (1973), Fishelson *et al.* (1974), Hobson(1974), Goldman and Talbot (1976), Fishelson (1977), Parrish and Zimmerman (1977) and Hobson and Chess (1978). The analyses of the diets of particular groups of fishes have been presented with an assessment of the relation between diet and what is available at the foraging site by Jones (1968) and Vivien and Peyrot - Clausade (1974).

The general aspects of the reproductive biology of the reef fishes have been given by many authors - Breder and Rosen (1966), Munro *et al.* (1973), Smith (1980) and Thresher (1984). Many have worked on the reproductive aspects of specific groups of reef fishes; chaetodontids: (Ralston 1976b, 1981, Burgess 1978, Reese 1981, Neudecker and Lobel 1982,1989, Aiken 1983, Gharibeh 1988, Gharibeh and Hulings 1990); pomacanthids: Lobel 1978, Moyer and Nakazono 1978a, Bauer and Bauer 1981, Thresher 1982, Moyer *et al.* 1983, Thresher and Brothers 1985) and pomacentrids (Fishelson

1970b, Keenlyside 1972, Robertson 1972, Moyer and Nakazono 1978, Thresher 1985, Madan Mohan *et al.* 1986b, Pillai *et al.* 1985a).

Several field studies on coral reef fish have focused on mating and social systems among various families: Chaetodontidae (Reese 1975, Lobel 1978, Neudecker and Lobel 1982, Robertson 1983, Thresher 1984, Moyer 1984, Fricke 1986, Colin and Clavijo 1988, and Colin 1989); Pomacanthidae (Moyer and Nakazono 1978, Moyer 1981,1984, Thresher 1982, Moyer *et al.* 1983, Wedge 1984, Thresher 1985); acanthurids (Randall 1961,Barlow 1974, Robertson 1983); pomacentrids (Reese 1964, Myrberg *et al.* 1967, Fishelson 1970b, Swerdloff 1970, Russel 1971, Allen 1972, Keenleyside 1972, Myrberg 1972a, b, Honda and Imai 1973, Fricke 1975b,1979, Fricke and Holzberg 1974, Moyer 1975, 1976, Moyer and Bell 1976, Mochek 1978,Thresher 1977, 1985, Thresher and Moyer 1983, Coats 1982, Doherty 1983, Jam 1986, Pankhurst 1990, Karino and Nakazono 1993, Hattori and Yamamuva 1995); labrids (Robertson 1972, Moyer 1974, Reinboth 1973, Meyer 1977, Robertson and Choat 1974, Robertson and Hoffman 1977, Warner and Robertson 1978, Warner and Hoffman 1980, Robertson 1981, Ross 1982,1984, Warner 1982, Warner and Schultz 1992); Scaridae (Randall and Randall 1963,Buckman and Ogden 1973, Choat and Robertson 1975) and Scorpaenidae (Fishelson 1975, Moyer and Zaiser 1981).

A historical resume of the marine fisheries research in Lakshadweep is given by James *et al.* (1986 a). Investigations on ornamental fishes of Lakshadweep conducted are storage, transportation and marketing by Anon (1986), James *et al.* (1986 b and 1987); resources by Murty *et al.* (1989); ecology and biology by Pillai *et al.* (1985 a, 1985b,1992, Pillai and Madan Mohan 1990), Madan Mohan *et al.*1986 b, Vijay anand 1990,a, 1994 and Vijay Anand and Varghese 1992 a.

The various aspects of ornamental fishes investigated in the present study are:

1. the species composition of ornamental fishes in Lakshadweep,
2. distribution and abundance of ornamental fishes in different habitats in the lagoon environment in relation to the hydrographic parameters namely temperature, salinity, dissolved oxygen and the nutrients namely phosphate, silicate, nitrate, nitrite and zooplankters in the different habitats,
3. length-weight relationship of selected species of ornamental fishes,
4. food and feeding habits of selected species and
5. reproductive biology of selected species.

□□□□□□

PLATE 1

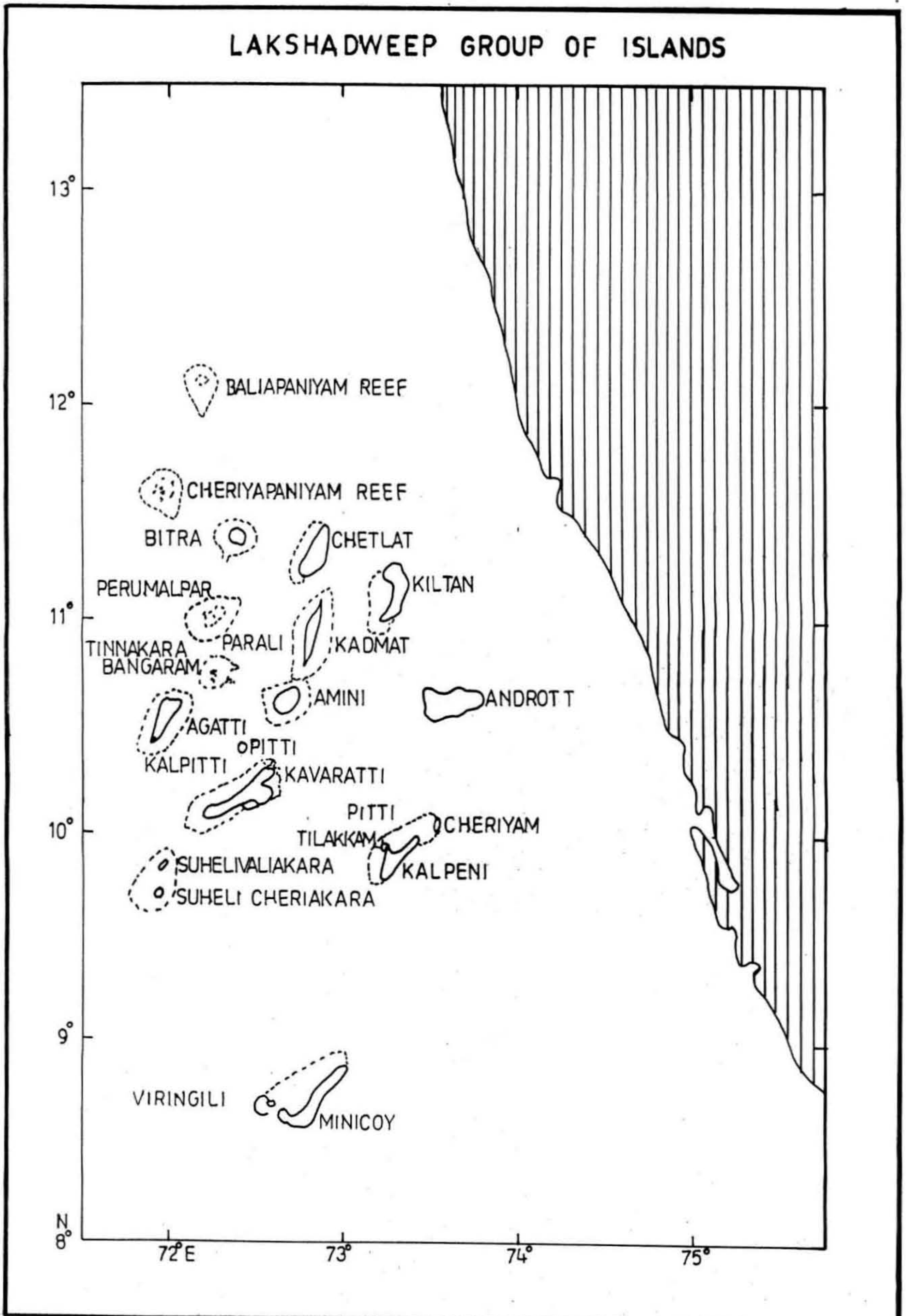

LAKSHADWEEP GROUP OF ISLANDS
BALIAPANIYAM REEF
CHERIYAPANIYAM REEF
BITRA
CHETLAT
KILTAN
PERUMALPAR
PARALI
KADMAT
TINNAKARA
BANGARAM
AMINI
ANDROTT
AGATTI
PITTI
KALPITTI
KAVARATTI
PITTI
CHERIYAM
TILAKKAM
KALPENI
SUHELIVALIAKARA
SUHELI CHERIAKARA
VIRINGILI
MINICOY
13°
12°
11°
10°
9°
N
8°
72°E
73°
74°
75°

PLATE 2

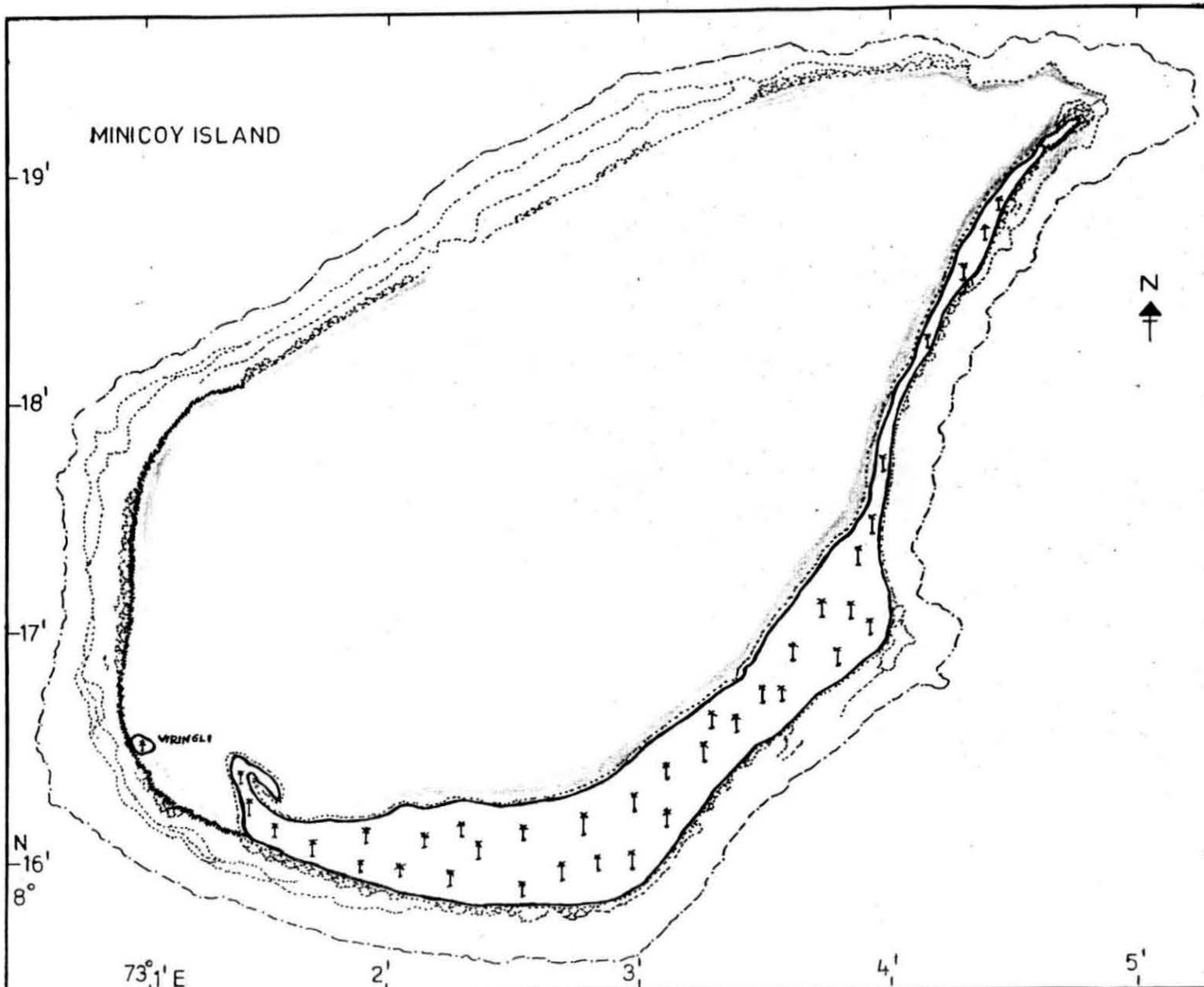
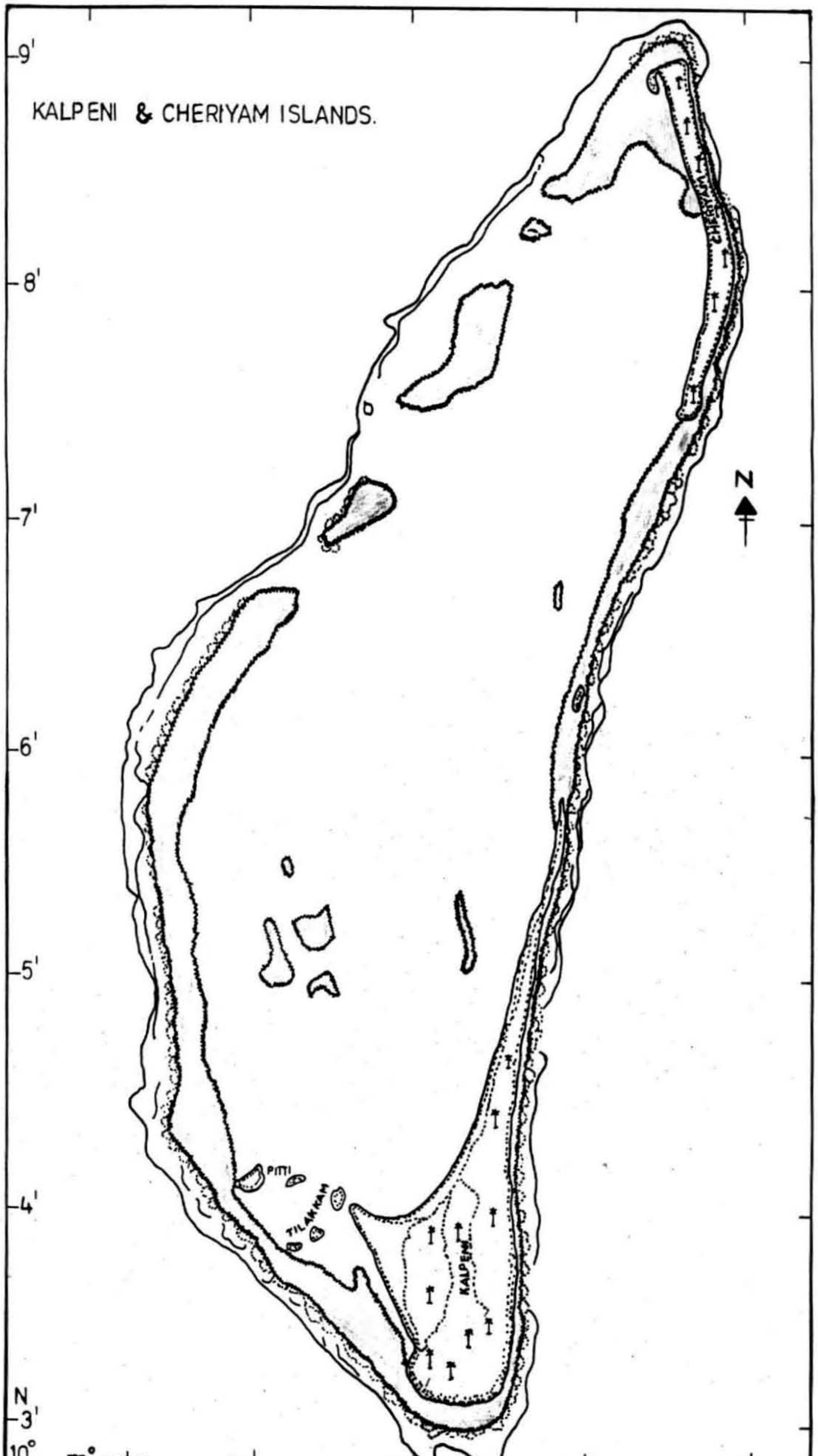


PLATE 3


KALPENI & CHERIYAM ISLANDS.
9'
8'
7'
6'
5'
4'
N
3'
10°
73° 36' E
37'
38'
39'
40'
N
CHERIYAM
KALPENI
PITTI
TILAKKAM

GENERAL MATERIALS AND METHODS

Pl. 4

For the study of species composition the fishes were collected from Minicoy, Kalpeni, Kavaratti, Agatti, Bangarum, Perumal Paar, Suheli Paar, Bitra, Cheriyapaniyam, Baliyapaniyam, Kiltan, Chetlat,Amini and Kadmat and the collection period was between january 1988 and March 1990. For the various studies for the hydrographic and zooplankton analysis, water and zooplankton samples were collected from Minicoy for a period from April 1988 to March 1990. Zooplankton samples were collected by towing for 10 minutes using standard zooplankton net. The data were subjected to various statistical analysis for the various studies. For the biological studies fishes were collected from Minicoy from April 1988 to March 1990 and from Kalpeni from April 1989 to March 1990. The limited sampling from the latter island was on account of insufficient and irregular inter island transport facilities, especially during monsoon seasons.

Jones and Kumaran (1959)gave an account of the fishing industry with special reference to Tuna fishery. The various indegenous fishing methods and implements in Lakshadweep have been reported by Vijay Anand (1990). Murty *et al.* (1989) collected the ornamental fishes using dragnet, encircling and cast nets. In the present study fishes for the identification and the various biological studies from the lagoons were collected by Kallumoodal and encircling methods.

KALLUMOODAL

(Malayalam language, Kallu = stone, moodal = to cover)

Taking advantage of the hiding habits of certain coral fishes, slightly modified cast nets were used in this method. The net was provided with lead weights, but was devoid of closing line. During operation , the net was thrown over a coral rock in/under which, the fishes take refuge. The safely covered coral stone was shaken to scare the fish out into the net. Advantage of the cast net is that, it can be operated by one person and the fish caught can be retrieved without any damage. An expert fisherman can catch even moving fishes by casting the net as done in the open sea on the eastern side of the island (Fig. 1.2 & 1.3). Fish collection in the present study was done by adopting the former method in the lagoons and latter in the open waters on the eastern side of the islands.

In the case of large and immovable corals like *Porites* spp. or profusely branched *Acropora* spp., resident pomacentrid fishes such as *Chromis caeruleus, Dascyllus aruanus, D.trimaculatus* and *D.reticulatus* were lured to a near by clear space by offering minced fish and the net cast.

ENCIRCLING METHOD

The gear used was a nylon wall net of length 90 ms or over and height 2 - 3 ms and having lead weights and floats (fig. 1.4). Fairly large area in the lagoon can be encircled in an operation of this net. After encircling an area, the hiding fishes were scared out using coconut frond and gradually concentrated to a smaller spot from where they were fished. The operation of net requires a minimum of 4 to 5 people.

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PLATE 4

1.1

1. 2

1.3

1. 4

Fig. 1.1 Kallumoodal 1.2 & 1.3 Locating fish in the seaward reef area and throwing the cast net over them.
1.4 A view of the encircling net.

CHAPTER I

SPECIES COMPOSITION OF ORNAMENTAL FISHES OF LAKSHADWEEP

Pl. 5-22

1.1. INTRODUCTION

A total of 603 species of fishes belonging to 126 families were reported from Lakshadweep with the full details of their morphometric and meristic characters by Jones and Kumaran (1980). According to Murty *et al.* (1989), about 300 species belonging to over 40 families are ornamental fishes; they identified ornamental fishes of 138 species coming under 33 families in their study. Tomey (1986) identified fishes of 136 species under 29 families as ornamental fishes. The 138 fishes identified by Murty *et al.* (1989) and 136 fishes by Tomey (1986) are included in the 603 species reported by Jones and Kumaran (1980).

1.2. MATERIALS AND METHODS

Fishes were collected from Minicoy, Kalpeni and Kavaratti lagoons. But collections from Agatti, Bangaram, Perumal Paar, Suheli Paar, Bitra, Cheriapaniyam, Baliyapaniyam, Kiltan, Chetlat, Amini and Kadmat during Cruise No:41 of FORV Sagar Sampada for Tuna Live - bait Fishery Survey around Lakshadweep islands from 20.1.88 to 1.2.88 were also included, since the author participated in the Cruise in connection with the present study.

Eventhough the lagoons of Lakshadweep islands harbour a wide variety of ornamental fishes, the islanders have not developed any aquaristic hobbies. However the Directorate of Fisheries , Kavaratti is maintaining ornamental fishes in the aquariums in view of Tourism enhancement. Aquarium fishes belonging to the families Labridae, Scaridae, Serranidae and Acanthuridae are consumed as food in all islands, especially during off seasons for tuna fishery. Ornamental fishes of the family, Pomacentridae namely, *Chromis caeruleus*, Apogonidae namely, *Paramia quinquilineata, Rhabdamia gracilis, Archamia fucata, Apogon quadrifasciatus* and *Ostorhinchus apogonides* are used as tuna live - baits by the fisherman. Excepting these species there is no fishing for ornamental fishes in Lakshadweep.

For the present study fishes were collected by both kallumoodal and encircling methods and were identified with the help of Carcasson (1977), Jones and Kumaran (1980) and Smith and Heemstra (1986).

1.3. ORNAMENTAL FISHES COLLECTED

A total of 169 species were collected which belong to 18 different families. Families Chaetodontidae and Pomacanthidae are exclusively ornamental fishes. Other important families in respect of aquaristic value are: Holocentridae, Pomacentridae, Labridae, Scaridae, Acanthuridae, Zanclidae, Platacidae, Cirrhitidae, Gobiidae, Lutjanidae, Apogonidae, Scorpaenidae, Balistidae, Monacanthidae, Ostracidae and Canthigasteridae.

1.3.1. FAMILY HOLOCENTRIDAE

The family is divided into two subfamilies, Holocentrinae and Myripristinae.

1.3.1.1. Subfamily HOLOCENTRINAE Pl. 5

Seven species collected were *Holocentrus sammara* (Forsskål), *H.laevis* Günther, *H.spinifer* (Forsskål) *H.lacteoguttatus* Cuvier, *H.violaceus* Bleeker, *H.caudimaculatus* Rüppell and *Sargocentron diadema* (Lacépède).

1.3.1.2. Subfamily MYRIPRISTINAE Pl 5

Two species were identified during this study. They are, *Myripristis murdjan*(Forsskål) and *M.adustus* Bleeker.

1.3.2. Family CHAETODONTIDAE Pl 5 - 9

A total of 17 species were collected during this study. They are *Hemitaurichthys zoster* (Bennett), *Heniochus acuminatus* (Linnaeus), *H.monoceros* Cuvier, *Chaetondon meyeri*, Bloch and Schneider, *C.lunula* (Lacépède), *C.melannotus* Bloch and Schneider, *C.collare* Bloch, *C.citrinellus* Cuvier, *C.bennetti* Cuvier, *C.trifasciatus* Mungo Park, *C.xanthocephalus* Bennett, *C.falcula* Bloch, *C. auriga* Forsskål, *C.vagabundus* Linnaeus, *C.kleini* Bloch and *C.plebius* Gmelin. *C.plebius* has not been reported from Lakshadweep before.

1.3.3. Family POMACANTHIDAE Pl. 9

Three species were collected and they are, *Centropyge multispinis* (Playfair), *Pomacanthus imperator* (Bloch) and *P.semicirculatus* (Cuvier).

1.3.4. Family POMACENTRIDAE Pl.10 - 13

The 31 species identified are: *Amphiprion chrysogaster* Cuvier, *A.bicinctus* Rüppell, *A.nigripes* Regan, *Lepidozygous tapeinosoma* (Bleeker), *Dascyllus trimaculatus* (Rüppell), *D.reticulatus* (Richardson), *D.aruanus* (Linnaeus), *Chromis chrysurus* (Bliss), *C.caeruleus* (Cuvier), *C.simulans* Smith, *C.dimidiatus* (Klunzinger), *C.nigrurus* Smith, *Pomacentrus lividus* (Bloch and Schneider), *P.nigricans* (Lacépède), *P.albifasciatus* Schlegel and Müller, *P.albicaudatus* Baschierei - Salvadori, *P.pavo* (Bloch), *P.melanopterus* Bleeker, *Abudefduf bengalensis* (Bloch) *A. sexfasciatus* (Lacépède),*A.saxatilis* (Linnaeus), *A.sordidus* (Forsskål),*A.septemfasciatus* (Cuvier), *A.cingulum* (klunzinger), *Plectroglyphidodon lacrymatus* (Quoy and Gaimard), *A.dickii* (Lienard), *A.biocellatus* (Quoy and Gaimard),*A.uniocellatus*(Quoy and Gaimard), *A.xanthozona* (Bleeker), *A.zonatus* (Cuvier) and *A.glaucus* (Cuvier).

1.3.5. Family LABRIDAE Pl. 13 - 16

33 labrid species collected during the study are: *Anampses caeruleopunctatus* Rüppell, *A.amboinensis* Bleeker, *A.diadematus* Rüppell, *Cheilio inermis* (Forsskål), *Gomphosus coeruleus* Lacépède, *G.varius* Lacépède, *Thalassoma*

amblycephalus (Bleeker), *T.hardwicki* (Bennett), *T.lunare* (Linnaeus), *T.purpurea* (Forsskål), *T.quinquevittata* Lay and Bennett, *T.jenseni* (Bleeker), *Labroides dimidiatus* (Valenciennes), *Halichoeres scapularis* (Bennett), *H.hortulans* (Lacépède), *H.marginatus* Rüppell, *H.notopsis* (Valenciennes),*H.argus* (Bloch and Schneider), *Stethojulis axillaris* (Quoy and Gaimard), *S.phekadopleura* (Bleeker), *S.strigiventer* (Bennett), *S.trileneata* (Bloch and Schneider), *S.albovittata* (Bonnaterre), *Coris formosa* (Benett), *C.gaimardi* (Quoy and Gaimardi), *C.frerei* Günther, *Iniistius pavo* Valenciennes, *Novaculichthys taeniourus* Lacépède, *Cheilinus chlorurus* (Bloch), *C.oxycephalus* Bleeker, *C.undulatus* Rüppell, *C.trilobatus* Lacépède and *C.fasciatus* (Bloch).

1.3.6. Family SCARIDAE — Pl. 17

A total of 11 species have been collected during the present study. They are *Scarus harid* Forsskal, *S. sordidus* Forsskal, *S.taeniurus* (Cuvier and Valenciennes), *S.bataviensis* (Bleeker), *S.pectroralis* (Cuvier and Valenciennes), *S.janthochir* (Bleeker), *S.niger* Forsskål, *S.sexvittatus* Rüppell, *S.ghobban* Forsskål, *S.scaber* Valenciennes and *Callyodon jordani* (Jenkins).

1.3.7. Family ACANTHURIDAE

1.3.7.1. Sub family ACANTHURINAE — Pl. 17 - 19

The 10 species identified are, *Paracanthurus hepatus* (Linnaeus) *Zebrasoma scopas* (Cuvier), *Z.veliferum*

(Bloch), *Acanthurus leucosternon* Bennett, *A.lineatus* (Linnaeus), *A.aliala* Lesson, *A.triostegus* (Linneaus), *A.nigricans* (Linnaeus), *A.mata* Valenciennes and *A.elongatus* Lacépède. Among these *Z.scopas* (cuvier) has not reported from Lakshadweep before.

1.3.7.2. Subfamily NASINAE Pl. 18.

Six species were collected. They are *Naso lituratus* (Bloch and Schneider), *N.unicornis* (Forsskål), *N.brevirostris* (Valenciennes) and *N.vlamingi* (Valenciennes), *N.brachycentron* (Valenciennes) and *N.tuberosus* Lacépède.

1.3.8. Family ZANCLIDAE Pl. 19

Two species, *Zanclus cornutus* (Linnaeus) and *Z.canescens* (Linnaeus) were collected.

1.3.9. Family PLATACIDAE Pl. 19

Two species identified are, *Platax orbicularis* (Forsskål) and *P.teira*(Forsskål).

1.3.10. Family CIRRHITIDAE Pl. 20

Two species were identified namely, *Cirrhitus pinnulatus* (Bloch and Schneider) and *Paracirrhites forsteri* (Bloch and Schneider).

1.3.11. Family GOBIIDAE Pl. 20

Ten species were identified. They are, *Paragobiodon echinocephalus* (Rüppell), *Gobiodon rivulatus* (Rüppell) *G.citrinus,* (Rüppell), *Oxyurichthys microlepis* (Bleeker), *Ctenogobiops crocineus* Smith, *Acentrogobius ornatus* (Rüppell), *Amblygobius albimaculatus* (*Ruppell*), *Quisquilius eugenius* Jordan and Tuermana, *Qinhacae* and *Bathygobius fuscus* (Günther).

1.3.12. Family LUTJANIDAE Pl. 20

Three species were identified. They are, *Lutjanus Kashmira* (Forsskål), *L.gibbus* (Forsskål) and *L.bohar*(Forsskål).

1.3.13. Family APOGONIDAE Pl. 20

12 species were collected during this study. They are, *Rhabdamia gracilis* (Bleeker), *Archamia fucata* (Cantor), *Apogon leptacanthus* Bleeker, *A.sangiensis* Bleeker, *Pristiapogon snyderi* (Lordon and Evermann), *Apogonichthys ocellatus* (Weber), *Ostorhychus nubilus* (Gawman), *O. Savayensis* (Günther), *O.quadrifasciatus* (Cuvier), *O.novemfasciatus* (Cuvier), *O.apogonides* (Bleeker) and *Paramia quinquelineata* (Cuvier).

1.3.14. Family SCORPAENIDAE Pl. 22

5 species were collected during this study namely, *Dendrochirus brachypterus* (Cuvier), *D.zebra* (Quoy and

Gaimard), *Pterois volitans* (Linnaeus), *P.antennata* (Bloch) and *P.radiata* (Cuvier).

1.3.15. Family BALISTIDAE Pl. 21

7 species were collected. They are, *Odonus niger* (Rüppell)*Canthidermis rotundatus* (Proce), *Melichthys niger* (Bloch), *Balistoides viridescens* (Bloch Schneider), *Balistapus undulatus* (Mungo Park), *Rhinecanthus rectangulus* (Schneider) and *R.aculeatus* (Linnaeus).

1.3.16. Family MONACANTHIDAE Pl. 22

4 species were identified. They are, *Oxymonacanthus longirostris* (Bloch and Schneider), *Paraluteres prionurus* (Bleeker), *Osbeckia scripta* (Osbeck) and *Amanses sandwichiensis* (Quoy and Gaimard).

1.3.17. Family OSTRACIDAE Pl. 22

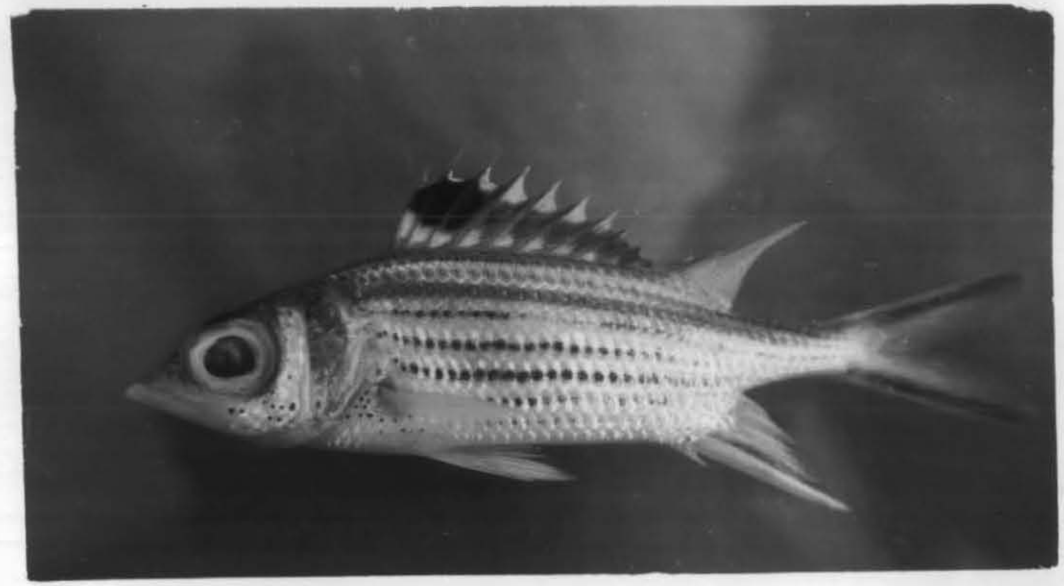
4 species identified are, *Lactoria cornuta* (Linnaeus) *Rhynchostracion nasus* (Bloch), *Ostracion cubicus* (Linnaeus)and *O.meleagris* Shaw.

1.3.18. Family CANTHIGASTERIDAE Pl. 22

4 species collected are, *Canthigaster amboinensis* (Bleeker),*C.cinctus*(Richardson), *C.margaritatus* (Rüppell)and *C.bennetti* (Bleeker).

PLATE 5

1.1



1.2

1.3

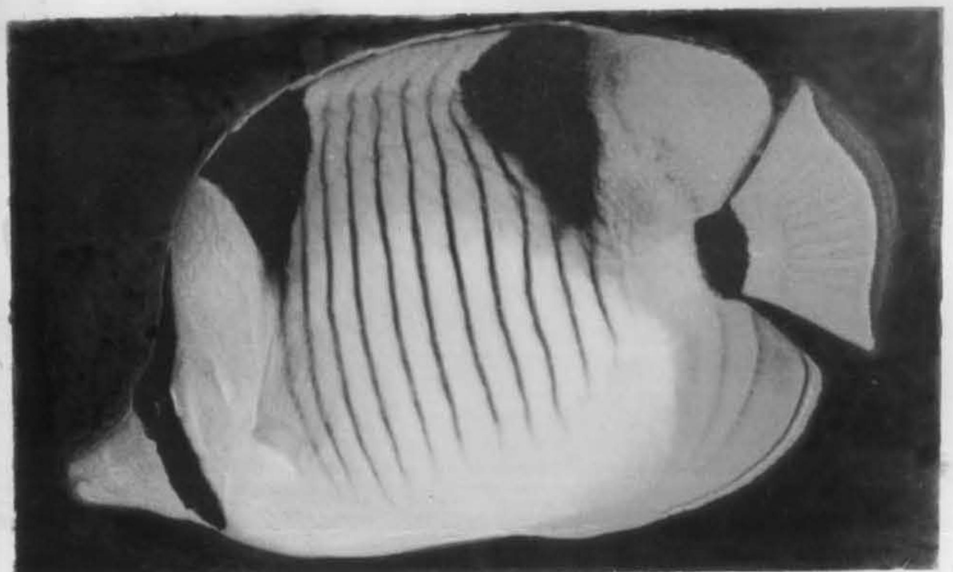
2.1

Fig. 1.1 *Sargocentron diadema* 9.1cm. 1.2 *Holocentrus sammara* 11.7cm. 1.3 *Myripristis murdjan* 10.5cm.
2.1 *Chaetodon lunula* 9.1cm.

PLATE 6

2.2

2.3



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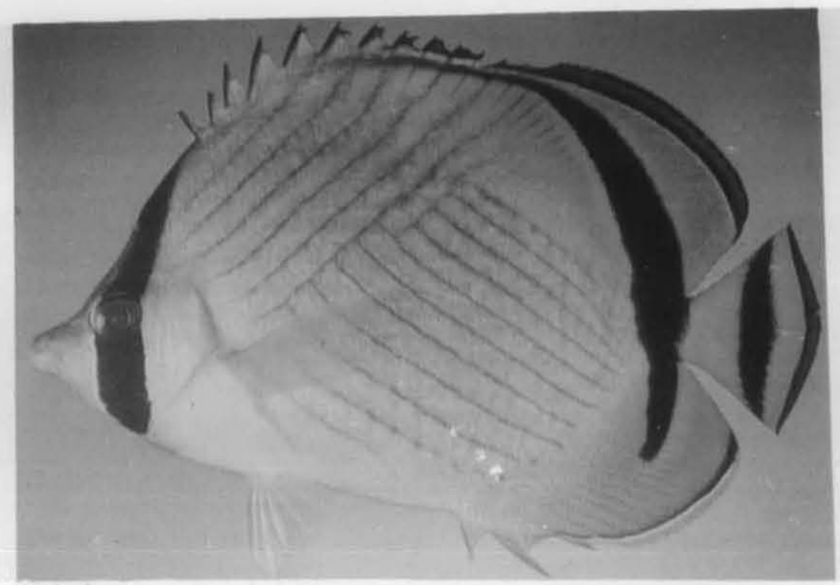


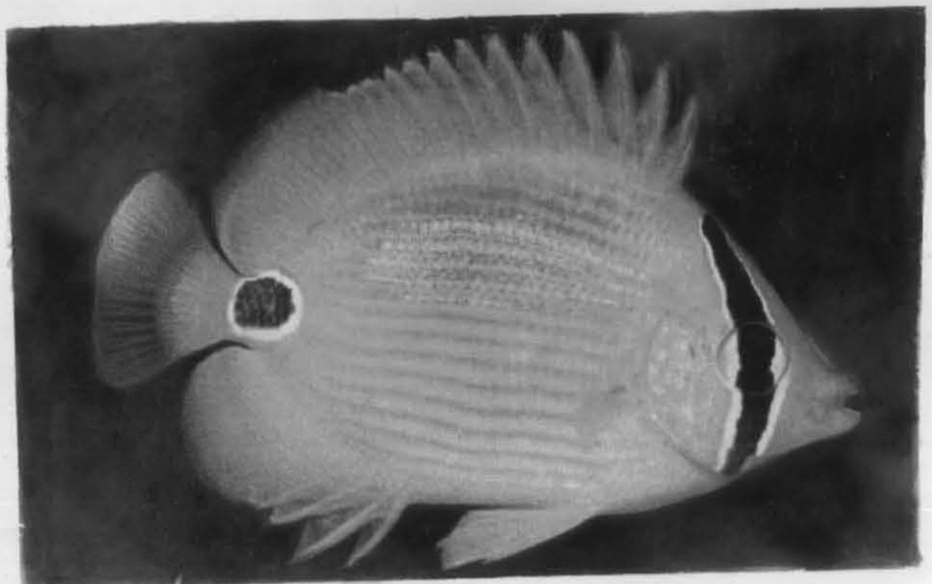
2.5

Fig. 2.2 Chaetodon auriga 6.9cm. 2.3 Chaetodon auriga 13.4cm. 2.4 Chaetodon falcula 13.8cm 2.5 Chaetodon vagabundus 11.4cm.

PLATE 7

2.6

2.7



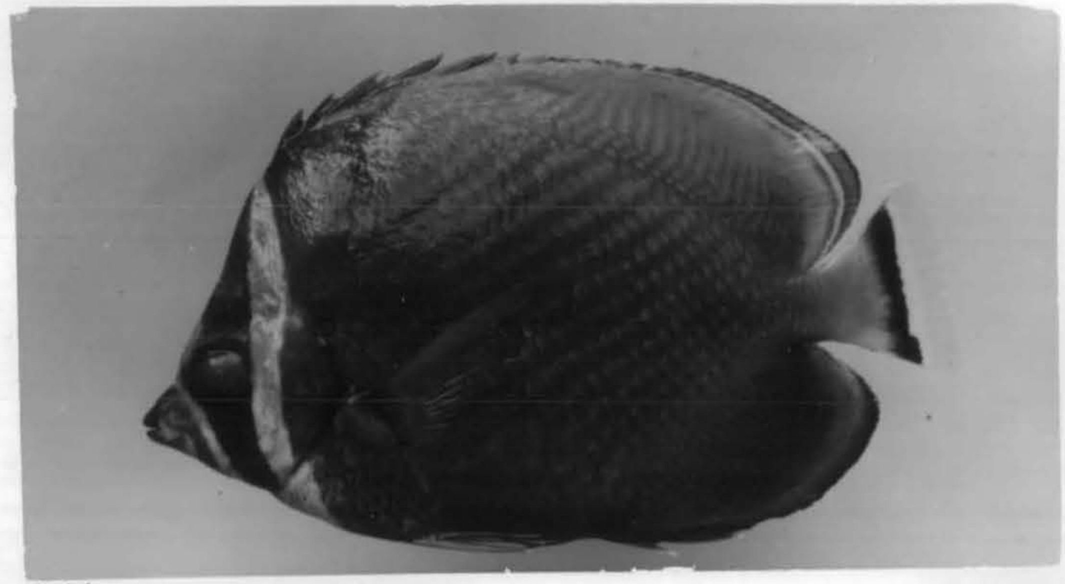
2.8

2.9

Fig. 2.6 Chaetodon xanthocephlus 8·4cm. 2.7 Chaetodon xanthocephalus 16cm. 2.8 Chaetodon plebius 9cm.
2.9 Chaetodon melanotus 8.9cm

PLATE 8

2.10



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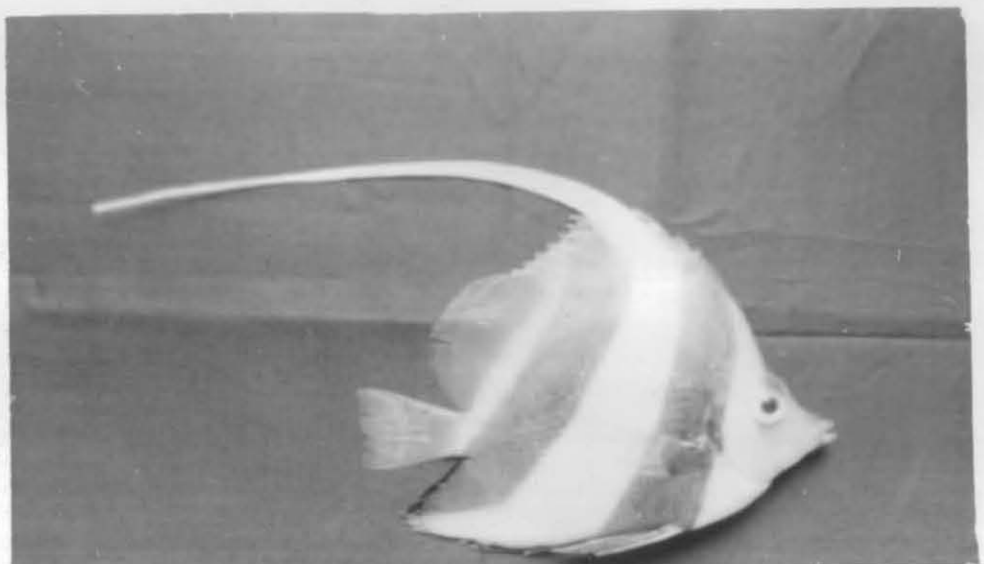


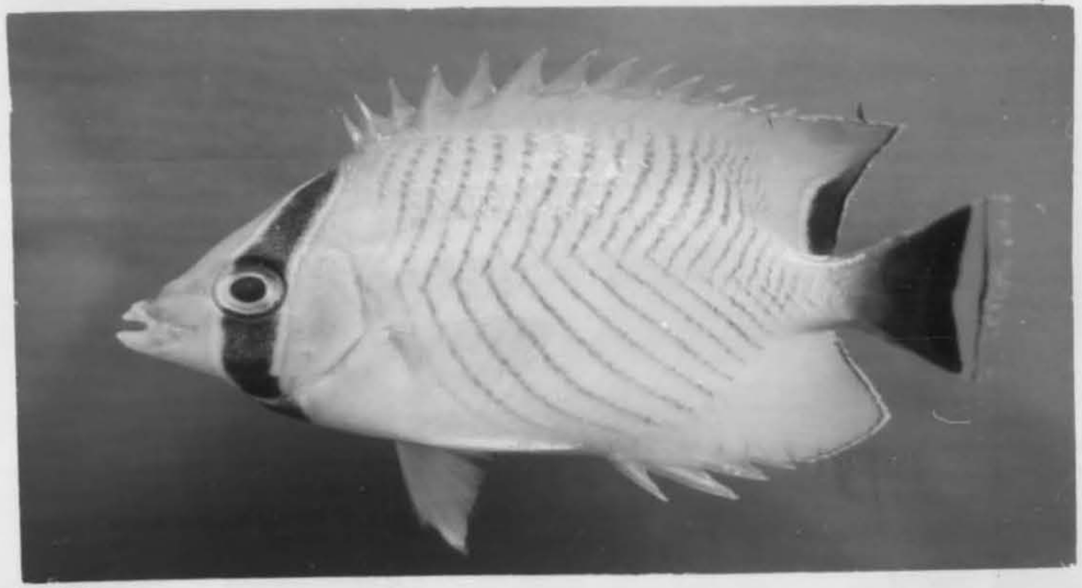
2.12

2.13

Fig. 2.10 Chaetodon citrinellus 7.9cm. 2.11 Chaetodon collare 14cm. 2.12 Heniochus acuminatus 10cm. 2.13 Heniochus monoceros 11.9cm

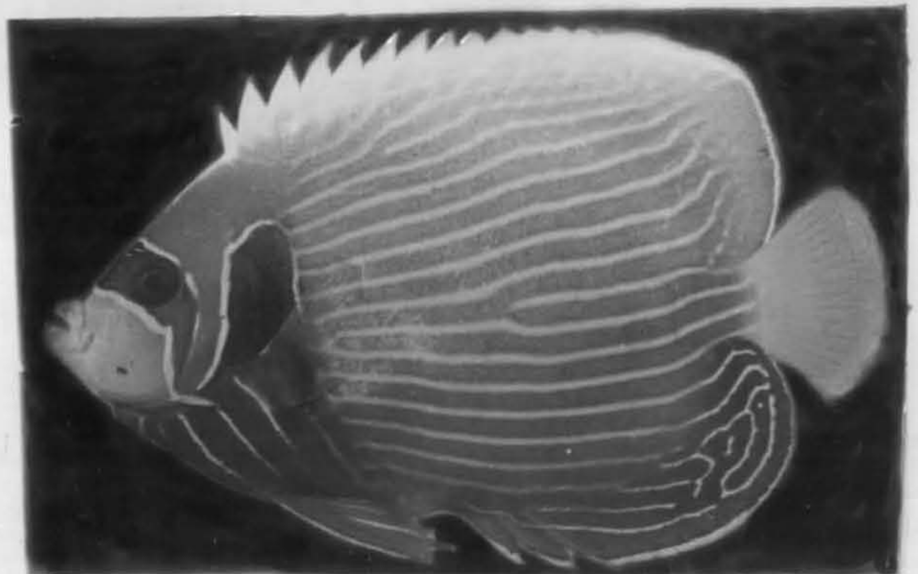
PLATE 9

2.14



2.15

3.1



3.2

Fig. 2.14 Chaetodon trifasciatus 8.3cm. 2.15 Chaetodon trifascialis 9.9cm. 3.1 Centropyge multispinis 7. 3cm.
3.2 Pomacanthus imperator 16.7 cm.

PLATE 10

4.1

4.2

4.3

4.4

Fig. 4.1 Chromis caeruleus 6.5cm. 4.2 Dascyllus aruanus 6.5cm. 4.3 Dascyllus trimaculatus 7.5cm. 4.4 Dascyllus reticulatus 4.7cm.

PLATE 11

4.5

4.6

4.7

4.8

Fig. 4.5 Amphiprion chrysogaster 7.5cm. 4.6 Abudefduf biocellatus 4.6cm. 4.7 Abudefduf cingulum 5cm.
4.8 Pomacentrus nigricans 6.7cm.

PLATE 12

4.9

4.10

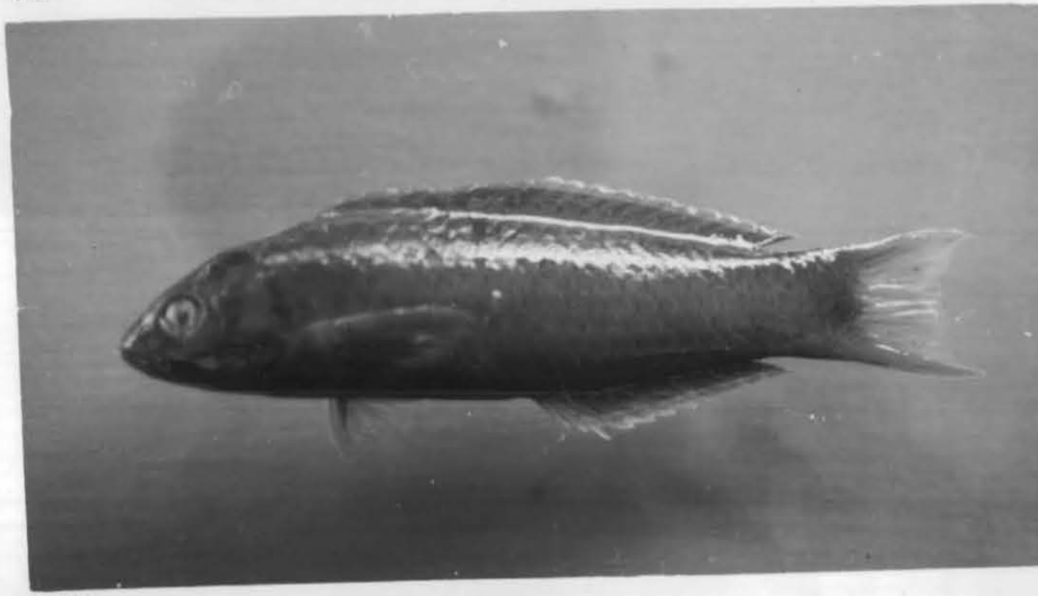
4.11

4.12

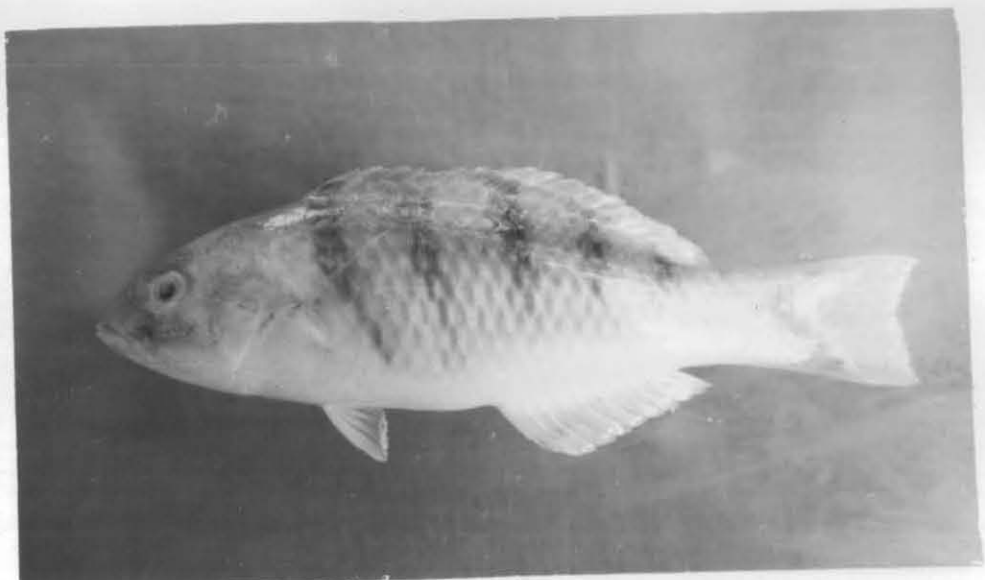
Fig. 4.9 Abudefduf sexfasciatus 9.8cm. 4.10 Abudefduf bengalensis 7.1cm. 4.11 Plectroglyphidodon lacrymatus 6.4cm.
4.12 Pomacentrus albifasciatus 6.1cm.

PLATE 13

4.13



5·1



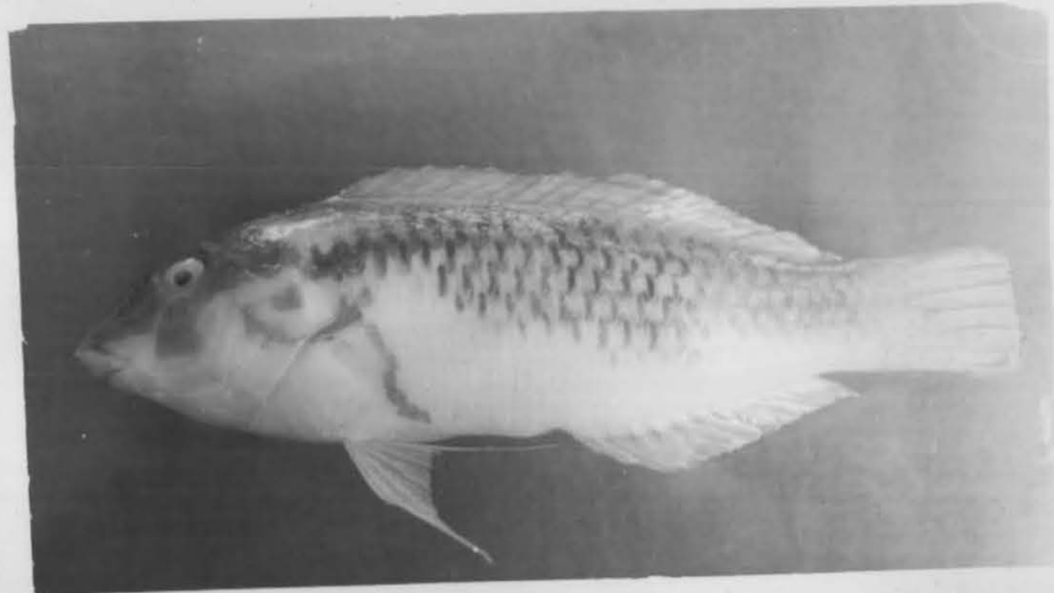
5·2

5·3

Fig. 4.13 Abudefduf dickii 6.5cm. 5.1 Thalassoma lunare 13cm. 5.2 Thalassoma hardwicki 11cm. 5.3 Thalassoma jenseni 12.1cm.

PLATE 14

5.4



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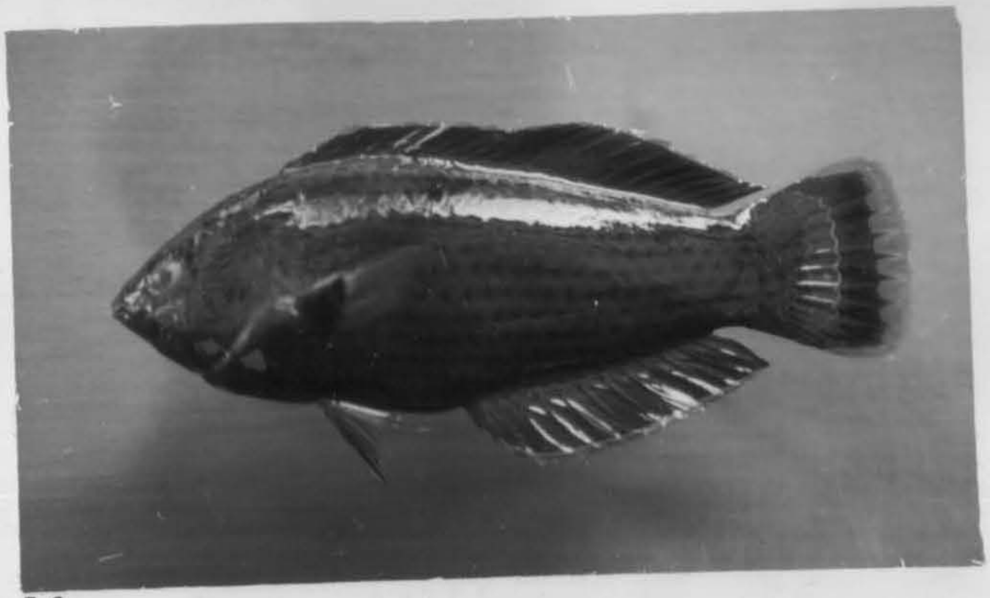

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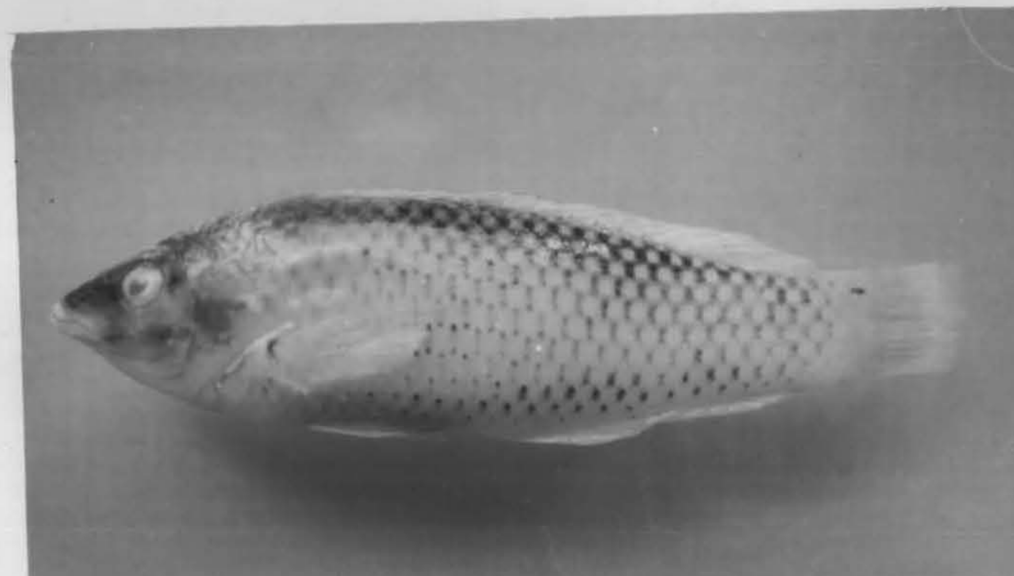
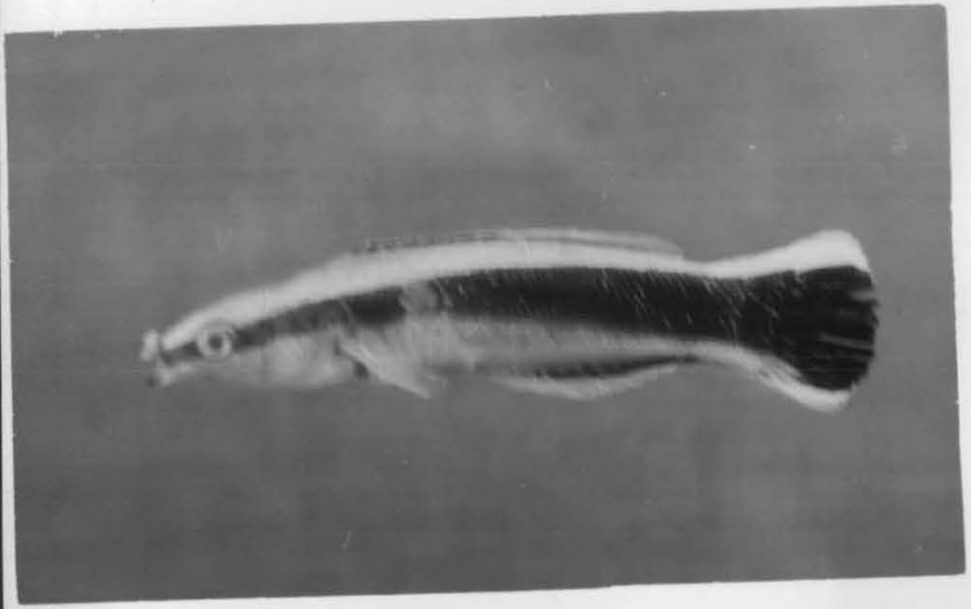


5.7

Fig. 5.4 Halichores scapularis 11·6cm. 5.5 Halichores scapularis 15·7cm. 5·6 Halichores marginatus 13·2cm.5.7 H.hortulans 13.2cm.

PLATE 15



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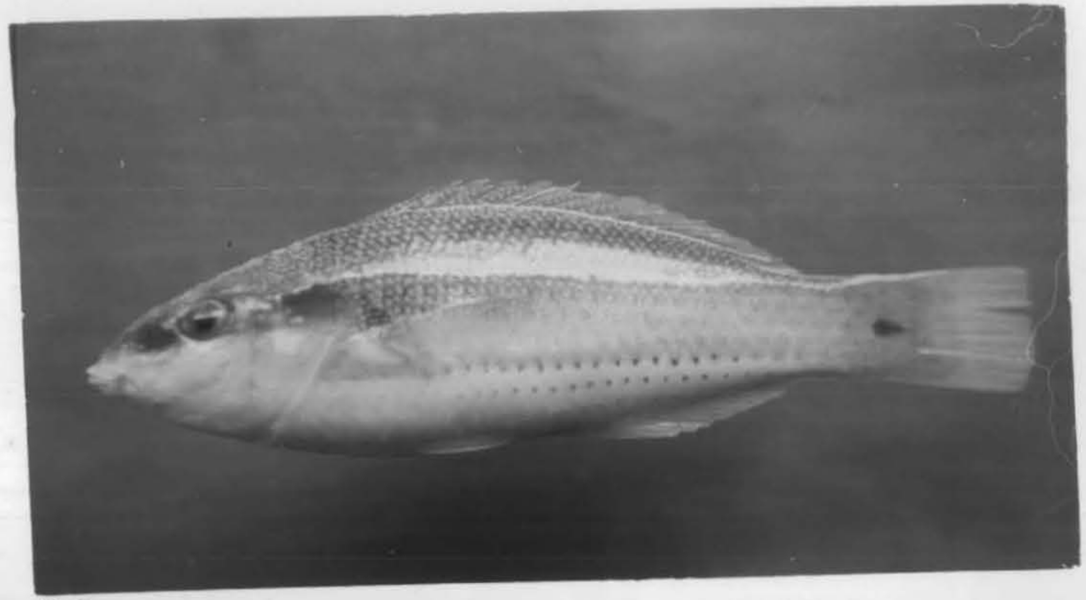

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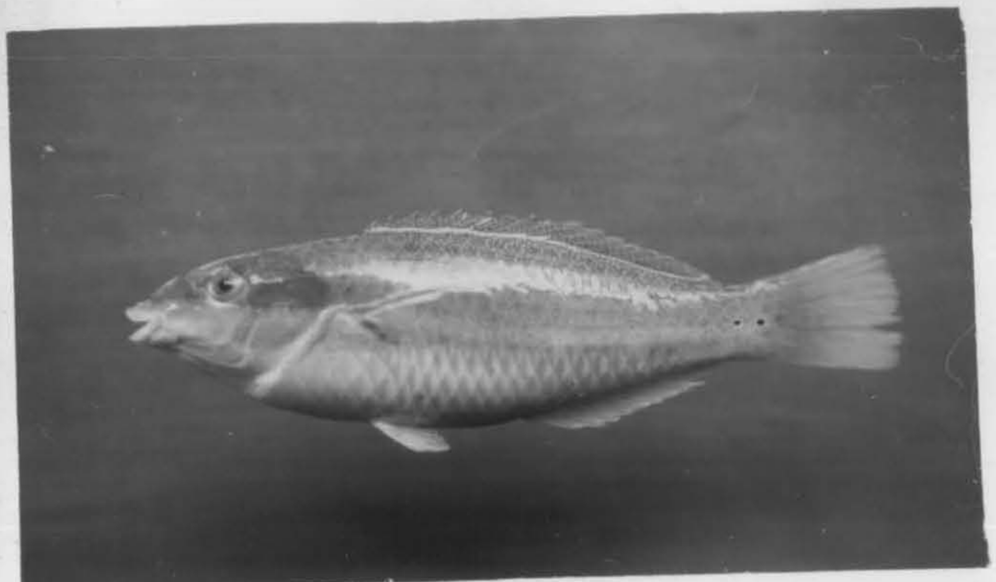

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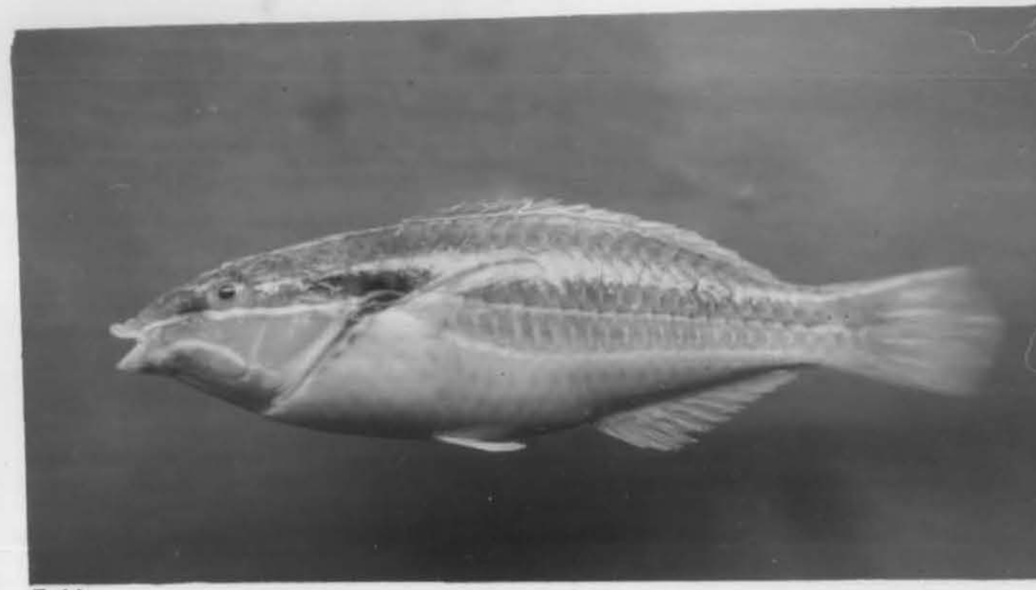
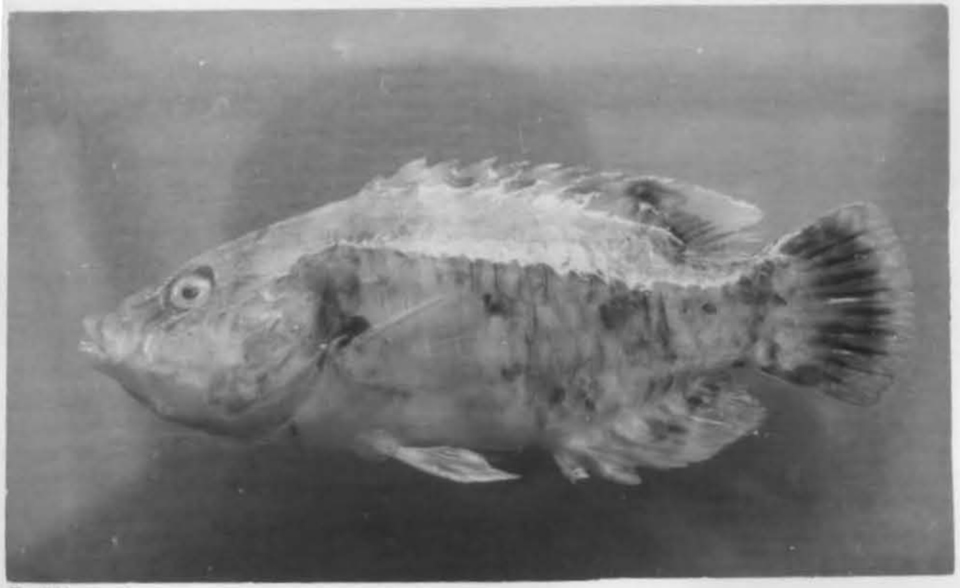


5.11

Fig. 5. 8 Labroides dimidiatus 4.4cm. 5.9 Stethojulis phekadopleura 10.5cm. 5. 10 Stethojulis albovittata (male) 10.3cm.
5.11 Stethojulis albovittata (female) 9.7cm.

PLATE 16



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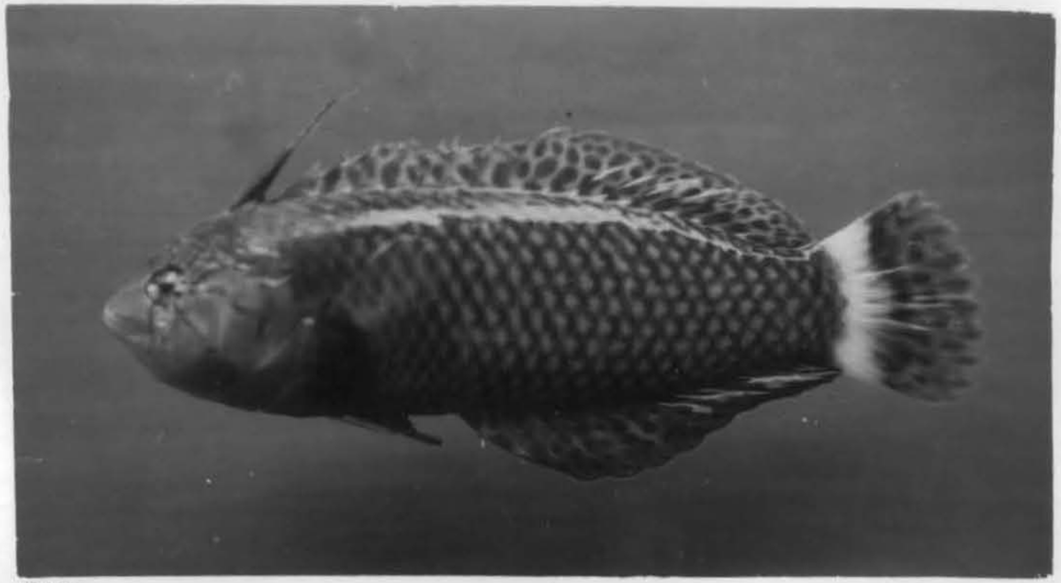

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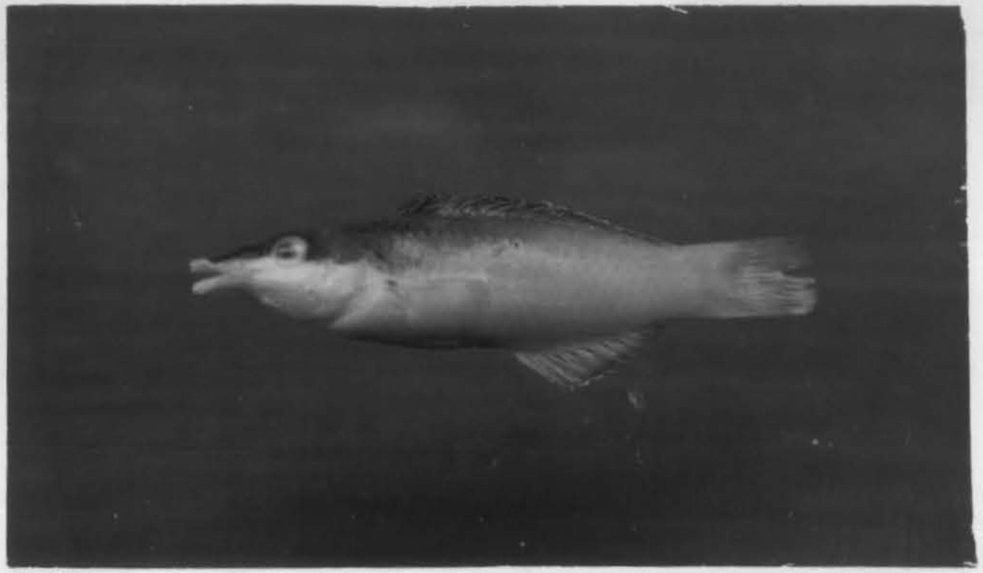
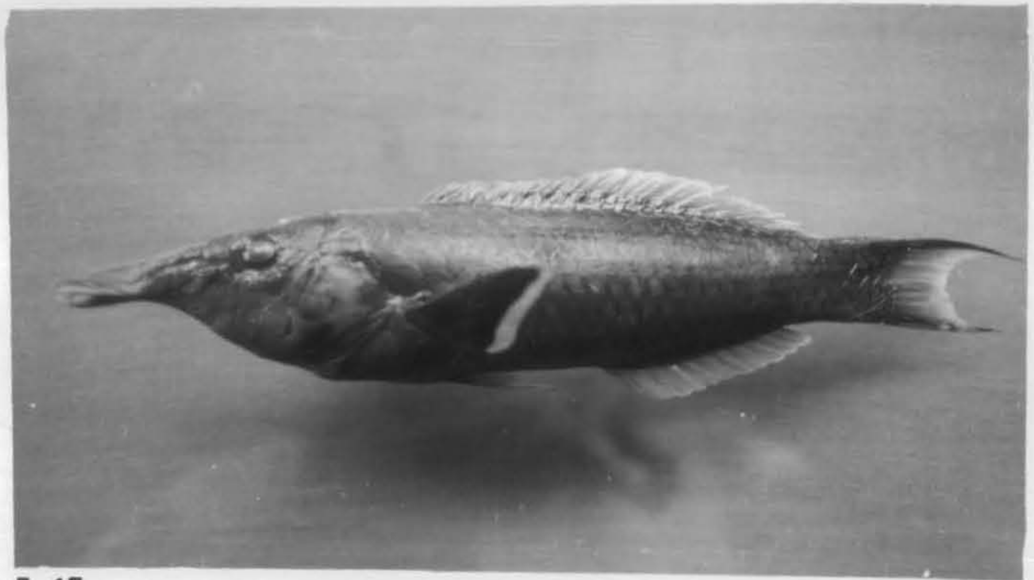


5. 14



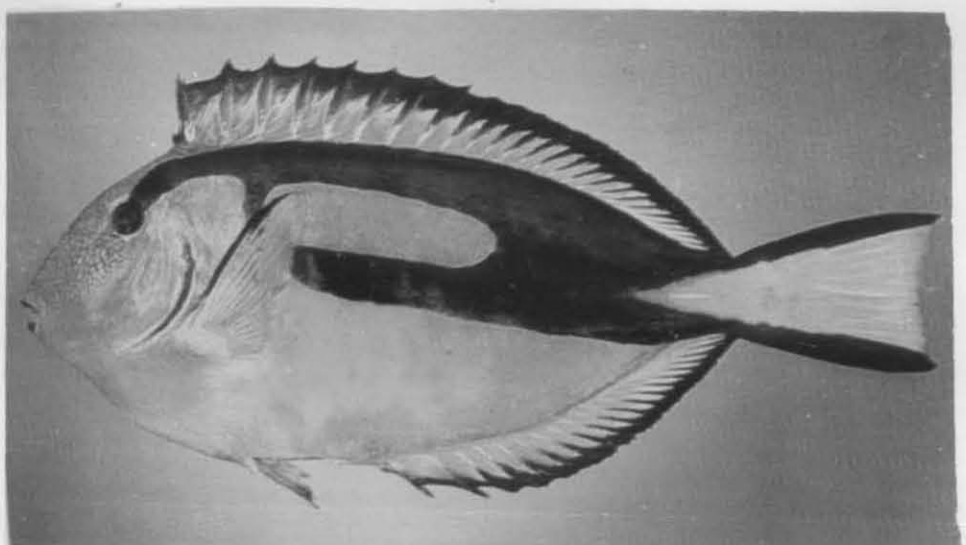
5. 15

Fig. 5.12 *Cheilinus trilobatus* 14cm. 5.13 *Novaculichthys taeniourus* 9.8cm. 5.14 *Gomphosus varius* 5.5cm. 5.15 *Gomphosus varius* 23cm.

PLATE 17

6.1

6. 2



7.1

7. 2

Fig. 6.1 Scarus bataviensis 19 5cm 6.2 Scarus ghobban 15.5cm. 7.1 Paracanthurus hepatus 20. 8cm. 7.2 Zebrasoma scopas 11cm.

PLATE 18

7.3

7.4

7.5

7.6

Fig. 7.3 Acanthurus leucosternon 13.2cm. 7.4 Acanthurus lineatus 13.6cm. 7.5 Acanthurus triostegus 10.6cm. 7.6 Naso brevirostris 17cm.

PLATE 19

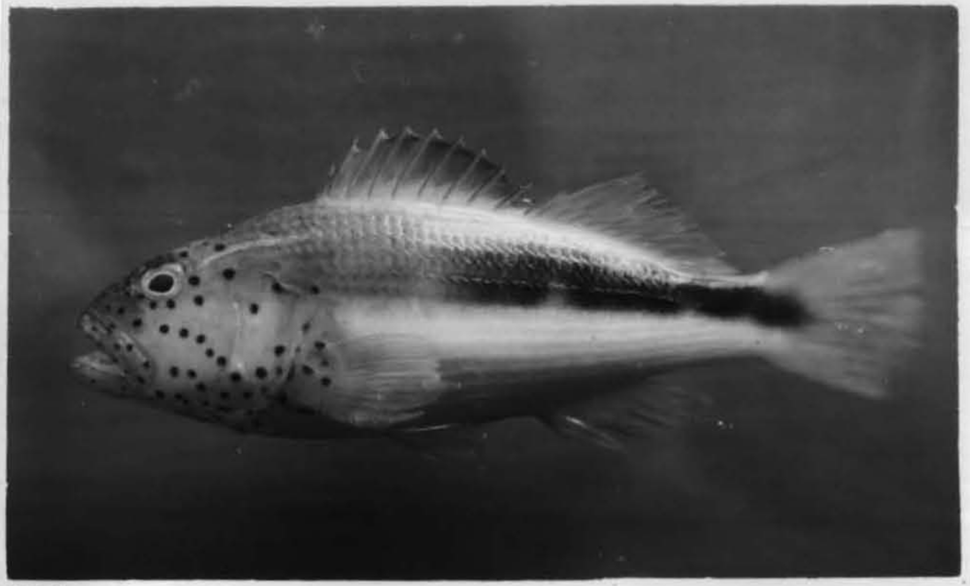
7.7

7.8

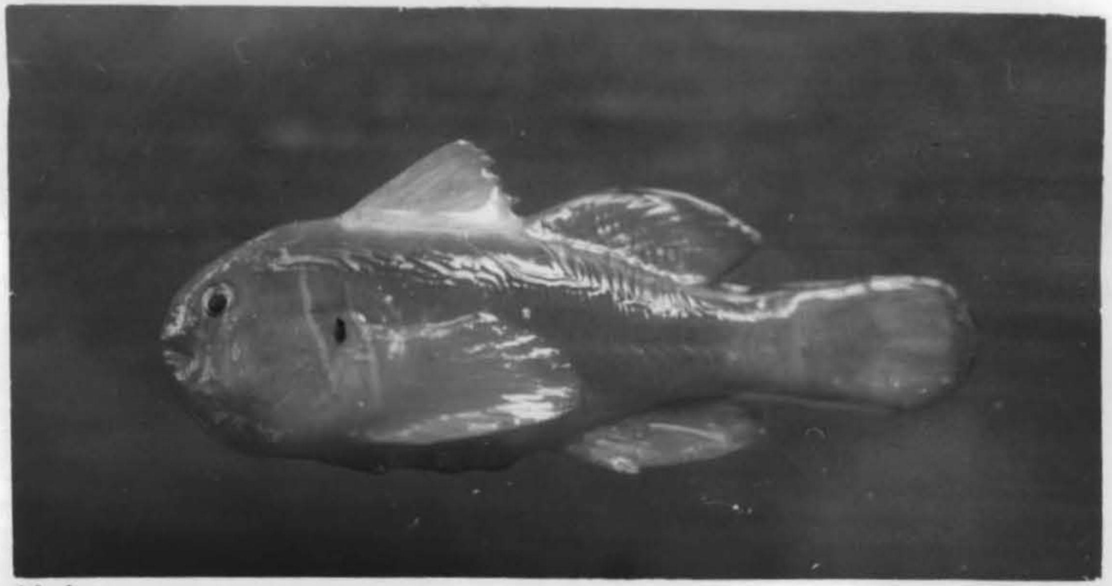
8.1

9.1

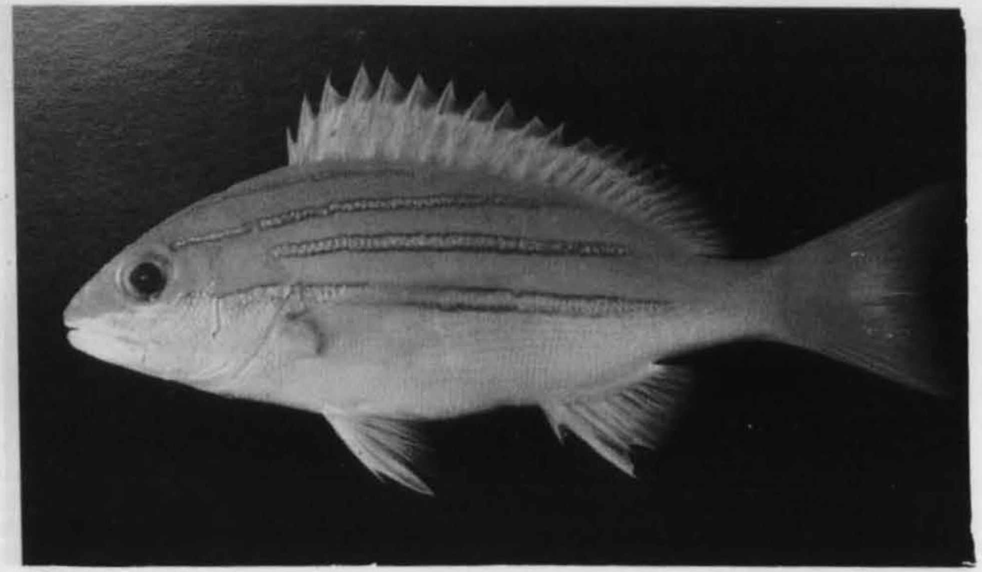
Fig. 7·7 Zebrasoma veliferum 5. 8cm. 7 . 8 Zebrasoma veliferum 10 · 2cm. 8 .1 Zanclus cornutus 10.6cm.
9·1 Platax orbilaris 8cm.



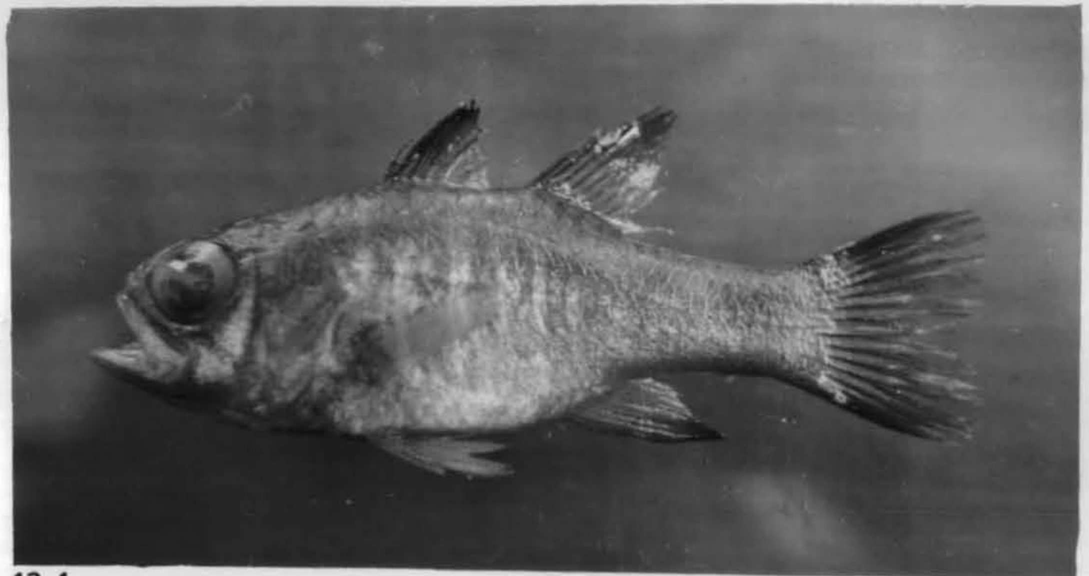
10.1



11.1



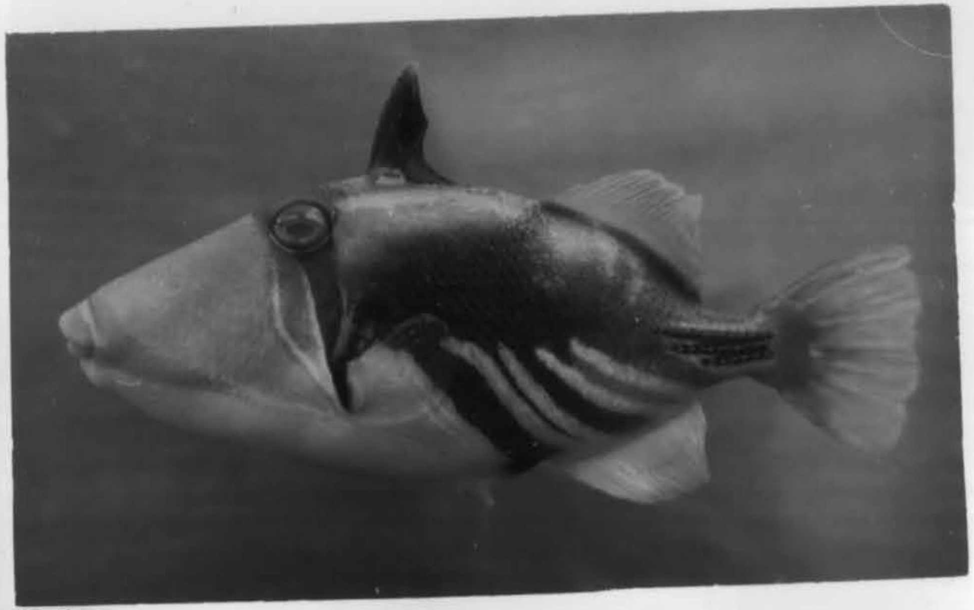
12.1



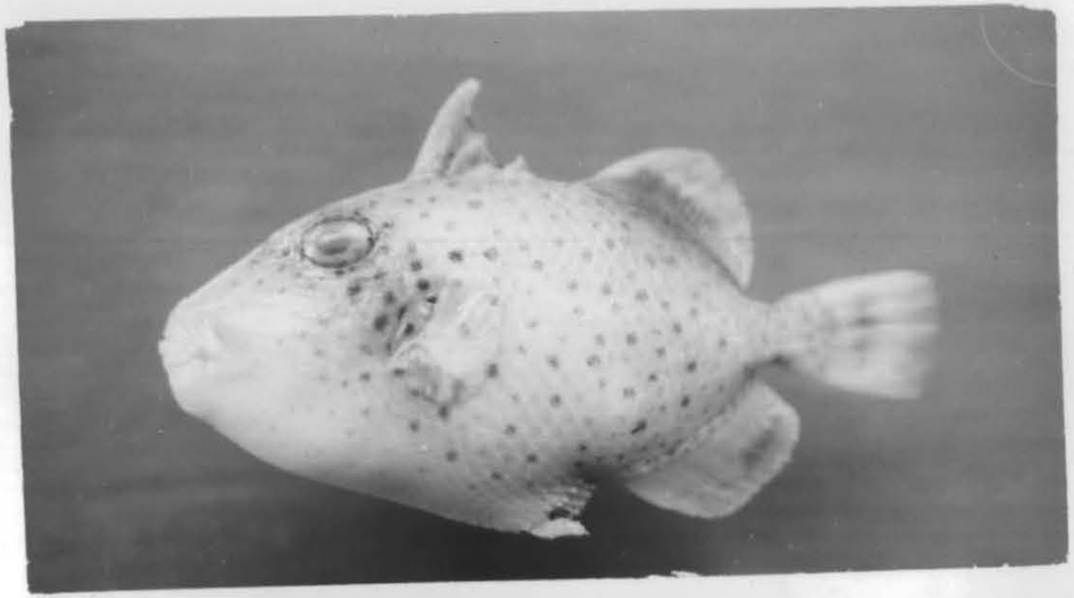
13.1

Fig. 10.1 Paracirrhites forsteri 11.1cm. 11.1 Gobiodon citrinus 5.6cm. 12.1 Lutjanus kashmira 12.3cm.
13.1 Ostorhynchus savayensis 8.2cm.

PLATE 21

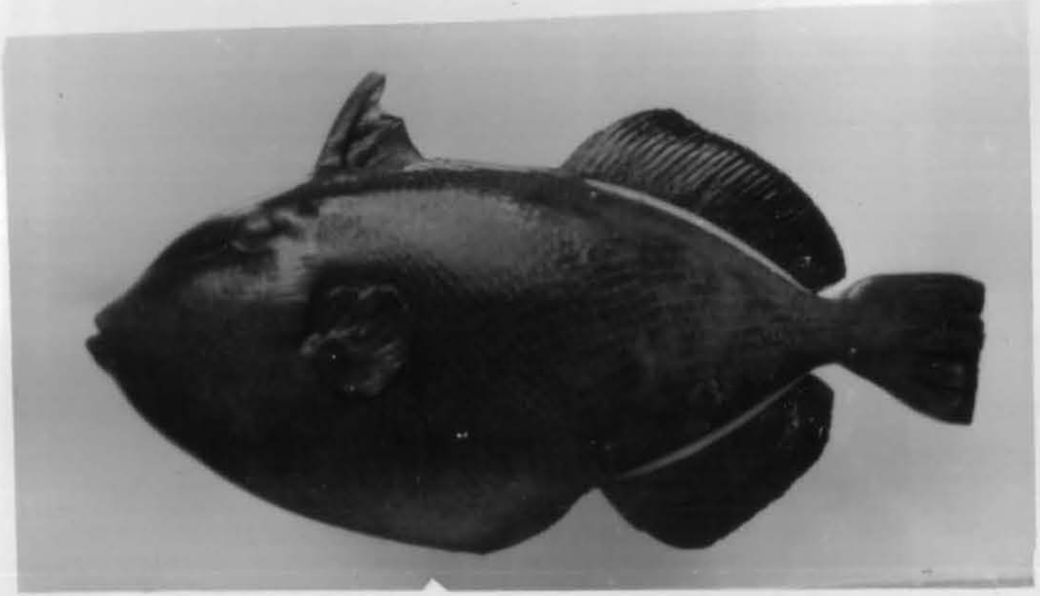


15. 1



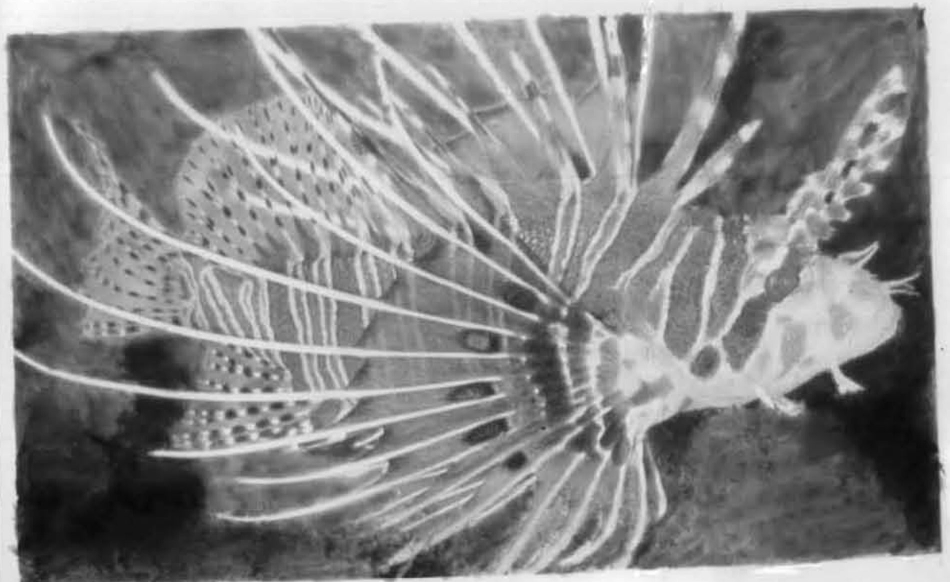
15. 2

15. 3

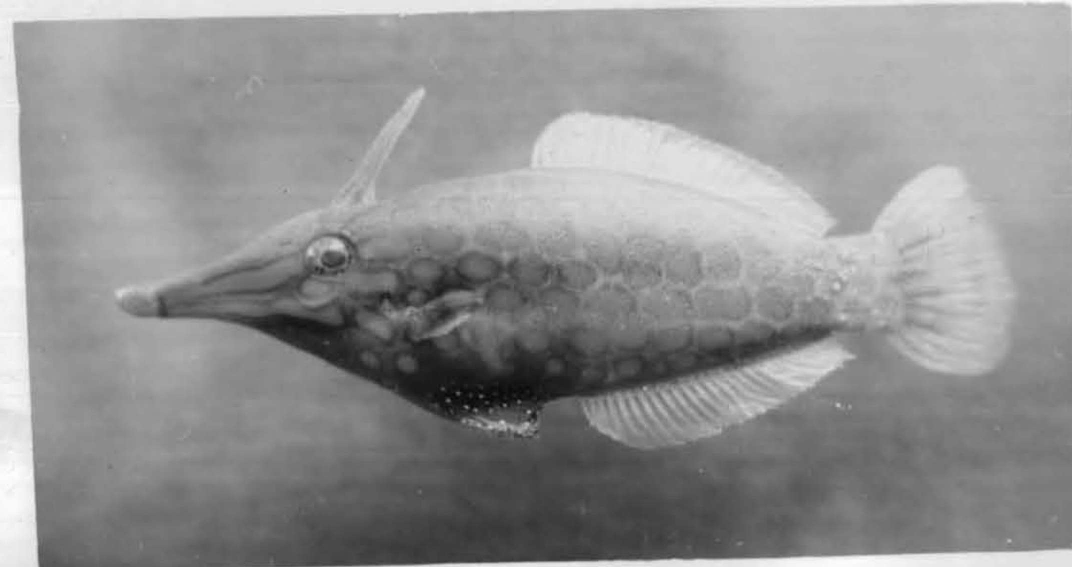


15. 4

Fig. 15.1 Rhinecanthus aculeatus 9.9 cm. 15.2 Canthidermis rotundatus 9cm. 15.3 Balistapus undulatus 22cm. 15.4 Melichthys niger 22.2cm.

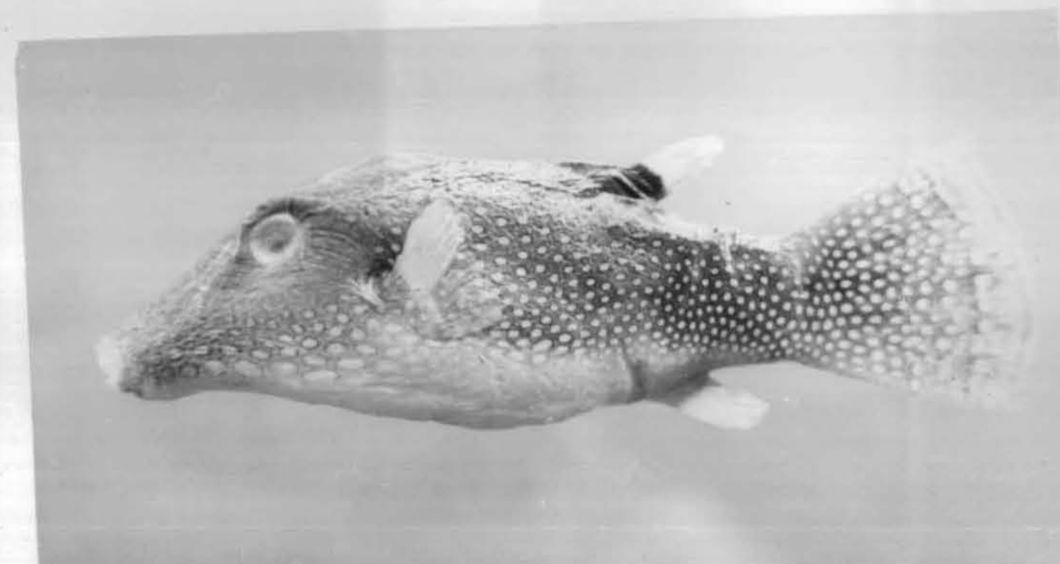


14.1



16.1

17. 1



18. 1

Fig. 14.1 Pterois antennata 18.5cm. 16.1 Oxymonacanthus longirostris 9cm. 17.1 Ostracion cubicus 5.5cm. 18.1 Canthigaster margaritatus 8.1cm.

CHAPTER II

DISTRIBUTION AND ABUNDANCE OF ORNAMENTAL FISHES IN THE MINICOY LAGOON

2.1. INTRODUCTION

Pl. 23-29

The coral reef fishes are those, that clearly are closely dependent upon the living coral substratum. Many of these are smaller fishes with specializations of colour, shape or behaviour that can be assessed as adaptations to life as coral reef inhabitants. A precise definition of a coral reef fish is probably neither possible nor desirable. Newell (1971) has traced the history of organic reef structures back to early paleozoic times and Smith and Tyler (1972) pointed out that the development of the acanthopterygian fishes that dominate coral reef biotopes has been closely synchronous with the development of modern coral - algal bioherms begining in the mid - mesozoic. Some coral reef fish species are members of taxa that probably have undergone most of their recent evolutionary history in coral reef environment; others belong to taxa typical of habitats other than coral reef environments. Gobiids, pomacentrids, epinepheline serranids and chaetodontids are good examples of typical or primary coral reef fishes (Smith 1978).

The most important fact is that within the coral reef fish community, there is a wide range of interactions between individuals of the same and different species, between fishes and invertebrates and between the fishes and nonbiological factors such as temperature, light and depth. These interactions range from simple shelter seeking and predator - prey relation to highly complex and stereotyped symbiotic associations involving structural and behavioural coadaptations.

The importance of plankton in meeting the energy requirements of coral reef ecosystem is also well known. However, Odum and Odum (1955) and Johannes *et al.* (1970) are of the opinion that drifting net plankton is inconsequential as an energy source, but may be important as a source of phospherous or of other essential nutrients. The role of plankton as an important food source also is well known (Yonge 1930 a, Emery 1968, Tranter and George 1972 and Goreu *et al.* 1971). Apart from the nutritional value of zooplankton for the corals, many of the reef fishes are also zooplankton feeders.

The fish communities associated with the coral reefs are the most complex and diverse known (Sale, 1974). The high diversity of coral reef fish communities includes a large within habitat component (Goldman and Talbot, 1976), wherein large numbers of species may co - occur in a very small space (Smith and Tyler, 1972). A part of this diversity can be accounted for by the fact that different parts of a coral reef may contain quite different assemblages of species (Sale, 1974). The diversity of species within any single reef habitat is also high (Talbot, 1970). It has been supported by Sale (1977, 1978) also. Other author(Smith, 1978) has emphasized the importance of adaptive responses to competition of predation in structuring these communities. A region may support more species than would be predicted from the available resources if potential competitors occupy different patches, thereby avoiding direct contact with each other (Clarke, 1977). According to Hulbert (1971), the reef fish populations typically are of quite high diversity, both because they contain a large number of species and because these are of relatively similiar relative abundances.

The Minicoy lagoon environment consisted of five distinct habitats namely, the coral bed, reef flat, sand bed, sea grass bed and the habitat with a mixture of sand and coral rubbles with attached sea weeds. Hence in the present study the hydrographic parameters namely temperature, salinity, dissolved oxygen and the nutrients namely phosphate, silicate, nitrate and nitrite and zooplankters in the above five habitats were analysed inorder to understand their relationship, if any, with the distribution and abundance of ornamental fishes in these habitats.

2.2. REVIEW OF LITERATURE

The marine fauna of Minicoy atoll has been reported by Nagabhushanam *et al.* (1972) and the distribution and abundance of ornamental fishes in the Lakshadweep lagoon by Murty *et al.* (1989). Jones and Kumaran (1980) have reported a total of 603 species of various fishes from Lakshadweep reefs.

The importance and the special ecological conditions of these waters have been reported by Cooper (1957) and Jones (1959 c). Jayaraman *et al.* (1959, 1960) have studied the oceanographic conditions of the Lakshadweep sea. Rao and Jayaraman (1966, 1970) and Girijavallabhan *et al.* (1989) have reported the hydrographic characteristics of the Lakshadweep.

The previous works on the zooplankton of the Lakshadweep coral reef ecosystem are that of Tranter and George (1972), Goswami (1973, 1979, 1983) and Madhu Pratap *et al.* (1977).

2.3. MATERIALS AND METHODS

Pl. 23

The five habitats selected for the study of distribution and abundance of ornamental fishes in the Minicoy lagoon are shown in Plate 23. They are:-

1. **Coral bed:** These were the extensive shoals of corals scattered at the central, deeper part of the lagoon. Presence of thick and abundant living corals could be noticed. The dominant corals were *Porites, Acropora, Diploastrea, Heliopora* and *Goniastrea.*

2. **Reef flat area:** The reef flat area in the southern part of the lagoon extending upto the Viringli island. The corals present in this area were *Fungia, Favia, Platygyra, Goniastrea, Porites, Pocillopora, Heliopora* and *Acropora.* This region of the reef flat was subjected to high wave actions and becomes exposed during extreme low tide. Most of the corals were dead and were remained scattered.

3. **Sand bed:** Towards the southern region of the lagoon there was an extensive area of sand, without coral, either dead or alive, seagrass or seaweeds.

4. **Mixed bottom:** The portion of lagoon in between the Viringli and Minicoy islands consisted of small patches of live corals with attached sea weeds. Corals observed in this area were *Porites leutea, Heliopora* spp., *Acropora humilis* and *A.formosa*. There was a long stretch of dead *Acropora* corals. Dead *Heliopora* spp. were also commom. The seaweeds observed were *Turbinaria* sp. and *Padina* sp.

5. **Sea grass bed:** The near shore region of lagoon exposed to tidal fluctuations was almost a complete stretch of seagrass, comprising *Cymodocea rotunda, C.serrulata, Halophila ovata, Syringodium* spp. and *Thalassia hemprichii*.

The distribution and abundance of various ornamental fishes in these five habitats were studied for a period of two years from April 1988 to March 1990. The number of each species was counted by three persons moving in three directions during low tides for a period of 45 minutes in each habitat in the morning hours. The approximate area of each habitat studied was 28 m^2.

Water samples from the five habitats were collected for the estimation of dissolved Oxygen, Salinity, PO_4, Sio_3, No_3 and No_2. Temperature of the water samples also were recorded. Winkler method was followed to estimate Do_2, Mohr's method(Strickland and Parson, 1968) for salinity

FAO (Anon, 1975) method for Po_4, Sio_3, and No_2 and the method of Mullin and Reiley (1955) for No_3.

Monthly zooplankton samples were collected from the five stations by a 10 - minute tow in each habitat using a standard zooplankton net of 0.33 mm meshsize and o.5m mouth diameter which was tied to a boat fitted with Yamaha 15 HP OBM at a speed of 0.5 Km/hour. Sampling was done between 0700 and 0900 hours. The total volume of the zooplankton and volume of each group/species was estimated by displacement method.

2.4. RESULTS

A total of 55 species were observed in the different habitats during the present study. The number of species represented in different families in the five habitats is given in Table 2.1. The table shows that a maximum of 55 species were present in the coral bed habitat followed by 51 in the mixed bottom and 40 in the reef flat area. Only two *Chaetodon* species were found in the sand bed habitat and no other fishes represented in the 18 families were encountered during this study period. Except for one species of Platacidae, the distribution and abundance of ornamental fishes was almost same in the coral bed and mixed bottom habitats. Fishes belonging to the families Apogonidae, Scaridae, Holocentridae, Cirrhitidae and Lutjanidae were not found distributed in the reef flat area. Apart from this exception, the number of species in the other families remained more or less same as that of the

TABLE : 2.1. DISTRIBUTION OF TOTAL NUMBER OF SPECIES IN DIFFERENT FAMILIES IN DIFFERENT HABITATS

		No. of species represented in each habitat				
Sl No	Name of Family	Coral bed	Mixed bottom	Reef flat	Sand bed	Seagrass bed
1	Labridae	10	10	10	Nil	Nil
2	Pomacentridae	9	10	9	"	"
3	Chaetodontidae	9	8	8	2	"
4	Apogonidae	5	5	Nil	Nil	"
5	Acanthuridae	4	3	3	"	"
6	Scaridae	4	2	Nil	"	"
7	Scorpaenidae	3	3	3	"	"
8	Pomacanthidae	2	2	2	"	"
9	Holocentridae	2	2	Nil	"	"
10	Zanclidae	1	1	1	"	"
11	Canthigasteridae	1	1	1	"	"
12	Ostracidae	1	1	1	"	"
13	Cirrhitidae	1	1	Nil	"	"
14	Balistidae	1	1	1	"	"
15	Lutjanidae	1	1	Nil	"	"
16	Platacidae	1	Nil	1	"	"
	Total	55	51	40	2	Nil

coral bed and mixed bottom habitats. Table 2.2. shows the average number of fishes in each family observed in the three habitats in 45 minutes time. More number of fishes were observed in the coral bed habitat followed by the mixed bottom habitat and among the three habitats the lowest number of fishes was encountered in the reef flat area. Table 2.3 shows the specieswise distribution of the various ornamental fishes for the different habitats.

2.4.1. FAMILY LABRIDAE

Among the labrids, *Halichoeres scapularis*, *H.hortulans* and *Thalassoma jenseni* were observed every month and others were observed only frequently. The most abundant species was *H.scapularis*. The average number was 298 in the coral bed, 237 in the mixed bottom and 172 in the reef flat region. In the case of *H.hortulans*, it was 40 in the coral bed, 31 in the mixed bottom and 16 in the reef flat area. The distribution and abundance of *H.marginatus*, *T.purpurea*, *T.hardwickii*, *T.lunare*, *T.jenseni*, *N.taeniorus* and *Stethojulis axillaris*, however, did not show much variation between the three habitats, and all of these species were observed only frequently in the three habitats. *L.dimidiatus* was observed throughout the entire period of study in the coral bed and mixed bottom habitats, but only frequently observed in the reef flat area. Its average number was 10 in the coral bed, 9 in the mixed bottom and in the reef flat area it was 2.

TABLE : 2.2. AVERAGE NUMBER OF FISHES IN VARIOUS FAMILIES OBSERVED IN DIFFERENT HABITATS

Sl No.	Name of Family	Name of Habitat: Coral bed	Mixed Bottom	Reef Flat
1	Pomacentridae	1290	962	470
2	Labridae	390	308	221
3	Acanthuridae	130	95	95
4	Chaetodontidae	60	35	31
5	Scaridae	16	2	Nil
6	Pomacanthidae	13	10	3
7	Lutjanidae	11	5	Nil
8	Balistidae	11	9	5
9	Scorpaenidae	9	5	5
10	Canthigasteridae	7	4	5
11	Holocentridae	6	3	3
12	Zanclidae	5	3	2
13	Cirrhitidae	4	3	Nil
14	Ostracidae	3	1	2
15	Platacidae	3	Nil	4

BLE: 2.3. DISTRIBUTION AND ABUNDANCE OF ORNAMENTAL FISHES IN THE DIFFERENT HABITATS IN THE MINICOY LAGOON DURING 1988 - 90

Sl No	Name Of Species	Nature of occurance					Range of minimum and maximum number of fishes					Average number of fishes				
		C	M	R	Sg	Sn	C	M	R	Sg	Sn	C	M	R	Sg	Sn
1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	16	17
I	FAMILY LABRIDAE															
1	*Halichoeres scapularis*	T	T	T	N	N	266-331	210-255	154-191			298	237	172		
2	*H.hortulans*	T	T	T	N	N	35-47	21-41	10-20			40	31	16		
3	*H.marginatus*	F	F	F	N	N	0-16	0-10	0-6			10	6	4		
4	*Thalassoma purpurea*	F	F	F	N	N	0-7	0-4	0-5			5	2	3		
5	*T.hardwickii*	F	F	F	N	N	0-8	0-5	0-6			5	3	4		
6	*T.lunare*	F	F	F	N	N	0-9	0-7	0-8			5	5	5		
7	*T.jenseni*	T	T	T	N	N	6-11	6-10	7-13			8	8	10		
8	*Labroides dimidiatus*	T	T	F	N	N	8-14	6-10	0-5			10	9	2		
9	*Novechulichthys taeniourus*	F	F	F	N	N	0-6	0-4	0-5			3	3	2		
10	*Stethojulis axillaris*	F	F	F	N	N	0-9	0-7	0-7			6	4	5		
II	FAMILY POMACENTRIDAE															
1	*Chromis caeruleus*	T	T	T	N	N	456-573	258-456	128-241			524	373	190		
2	*Dascyllus aruanus*	T	T	T	N	N	208-286	168-238	68-125			248	207	99		
3	*D.trimaculatus*	T	T	T	N	N	168-238	108-198	57-85			204	146	72		
4	*D.reticulatus*	T	T	T	N	N	146-216	109-164	53-85			184	138	68		
5	*Pomacentrus nigricans*	T	T	T	N	N	36-59	26-45	5-14			48	38	10		
6	*P.albifasciatus*	T	T	T	N	N	18-37	15-27	5-12			30	22	9		
7	*Abudefduf biocellatus*	T	T	T	N	N	13-26	10-15	4-10			20	13	7		
8	*A.unicellatus*	T	T	T	N	N	10-20	8-15	6-11			12	12	9		
9	*A.sexfasciatus*	T	T	T	N	N	12-23	7-14	3-9	0-6		17	10	6		
10	*Amphiprion chryogaster*	N	T	N	N	N		2-3					2			

Contd....

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
III	FAMILY CHAETODONTIDAE															
1	*Chaetondon auriga*	T	T	T	N	O	6-22	6-19	4-11		0-4	13	12	7		2
2	*C.lunula*	T	T	T	N	N	4-12	2-8	3-12			8	4	7		
3	*C.xanthocephalus*	T	T	T	N	O	4-14	4-12	3-12		0-4	8	7	8		2
4	*C.citrinellus*	T	T	T	N	N	5-13	3-5	3-6			8	4	4		
5	*C.kleini*	T	F	F	N	N	5-12	0-3	0-3			8	2	2		
6	*C.falcula*	T	F	F	N	N	4-12	0-6	0-8			8	3	3		
7	*C.melannotus*	T	O	F	N	N	2-6	0-3	0-3			4	1	1		
8	*C.trifasciatus*	T	O	O	N	N	2-6	0-3	0-3			4	1	1		
9	*C.trifascialis*	T	N	N	N	N	0-3					2				
IV	FAMILY APOGONIBAE						NOT COUNTED									
1	*Paramia quinquilineata*	T	T	N	N	N										
2	*Rhabdamia gracilis*	T	T	N	N	N										
3	*Archamia fucata*	T	T	N	N	N										
4	*Apogon thermalis*	T	T	N	N	N										
5	*A.apogonides*	T	T	N	N	N										
V	FAMILY ACANTHURIDAE															
1	*Acanthurus triostegus*	T	T	T	N	N	80-128	76-120	75-120			109	89	91		
2	*A.leucosternon*	T	F	F	N	N	6-15	0-6	0-2			11	3	1		
3	*A.lineatus*	T	N	F	N	N	3-5		0-6			4		3		
4	*Paracanthurus hepatus*	T	T	N	N	N	4-8	2-3				5	2	2		
VI	FAMILY SCARIDAE															
1	*Scarus bataviensis*	F	O	N	N	N	0-9	0-3				4	1			
2	*Scarus ghobban*	F	O	N	N	N	0-7	0-3				4	1			
3	*Scarus*	F	N	N	N	N	0-6					3				
4	*Scarus*	F	N	N	N	N	0-5					3				
VII	FAMILY SCORPAENIDAE															
1	*Pterois antennata*	F	F	F	N	N	0-5	0-4	0-4			3	2	2		
2	*P.volitans*	F	F	F	N	N	0-5	0-5	0-3			1	1	2		
3	*P.rabiata*	F	F	F	N	N	0-6	0-5	0-4			3	2	2		

Contd....

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
VIII	FAMILY POMACANTHIDAE															
1	*Centropyge multispinis*	T	T	F	N	N	8-12	6-10	0-3			10	9	1		
2	*Pomacanthus imperator*	T	T	F	N	N	1-5	1-2	0-3			3	2	1		
IX	HOLOCENTRIDAE															
1	*Holocentrus sammara*	F	O	O	N	N	0-6	0-3	0-3			4	1	1		
2	*Sargocentron diadema*	F	O	O	N	N	0-4	0-3	0-3			2	1	1		
X	FAMILY ZANCLIDAE															
1	*Zanclus canescens*	F	F	F	N	N	0-8	0-6	0-4			5	3	2		
XI	FAMILY CANTHIGASTERIDAE															
1	*Canthigaster margaritatus*	T	T	T	N	N	5-10	3-5	4-7			7	4	5		
XII	FAMILY OSTRACIDAE															
1	*Ostracion cubicus*	F	F	F	N	N	0-5	0-3	0-3			3	1	2		
XIII	FAMILY CIRRHITIDAE															
1	*Paracirrhites forsteri*	T	T	N	N	N	2-6	2-4				4	3			
XIV	FAMILY BALISTIDAE															
1	*Rhinecanthus aculeatus*	T	T	T	N	N	8-14	7-13	3-7			11	9	5		
XV	FAMILY LUTJANIDAE															
1	*Lutjanus kashmira*	T	T	N	N	N	8-14	2-8				11	5			
XVI	FAMILY PLATACIDAE															
1	*Platax orbicularis*	O	N	F	N	N	0-9		0-9			3		4		

C-Coral bed, M-Mixed bottom, R-Reef flat, Sg-Seagrass bed, Sn-Sand bed
T-Throughout, F-Frequently, O-Occassional, N-Not observed

2.4.2. FAMILY POMACENTRIDAE

More fishes were observed in the coral bed habitats and the lowest number in the reef flat area. Among pomacentrids, *C.caeruleus* was the most abundant species, the number of which was 524 in the coral bed, 373 in the mixed bottom and 190 in the reef flat area. It was followed by *D.aruanus*, the highest number observed was 248 in the coral bed , followed by 207 in the mixed bottom and 99 in the reef flat habitat. The number of *D.trimaculatus* was 204 in the coral bed habitat, 146 in the mixed bottom and 72 in the reef flat area. In the case of *D.reticulatus* the number noted was 184 in the coral bed, 138 in the mixed bottom and 68 in the reef flat area. *P.nigricans, P.albifasciatus, A.sexfasciatus, A.biocellatus* and *A.uniocellatus* also showed the same pattern of distribution. The highest number observed for *P.nigricans* was 48, that for *P.albifasciatus* was 30, for *A.sexfasciatus* was 17, for *A.biocellatus* was 20 and that for *A.uniocellatus* was 29 in the coral bed habitat. A pair of *Amphiprion chrysogaster* was observed in the mixed bottom associated with a seaanemone and a new recruitment to this pair observed from september 1989 onwards. Hence except for *A.chrysogaster*, the species composition of the pomacentrids was same in the three habitats. The only difference noticed was the variation in their number.

2.4.3. FAMILY CHAETODONTIDAE

More fishes were encountered in the coral bed habitat while less fishes in the reef flat. The average number of fishes in the case of *C.auriga* was 13 in the coral bed habitat, 12 in the mixed bottom and 7 in the reef flat area. The average number of *C.lunula* in the coral bed was 8, 4 in the mixed bottom and 7 in the reef flat area. For *C.xanthocephalus* it was 8, 7 and 8 in the coral bed area, mixed bottom and reef flat respectively. The number of *C.citrinellus* was 8,4 and 4 in the coral bed, mixed bottom and reef flat area respectively. *C.kleini* was observed only frequently in the mixed bottom and reef flat area and the number was 8,2 and 2 in the three habitats. *C.falcula, C.melannotus* and *C.trifasciatus* were not observed throughout the study period in the mixed bottom and reef flat habitats. Average number of *C.falcula* was 8,3 and 3 in the three habitats. The number of *C.melannotus* and *C.trifasciatus* was 4 in the coral bed and 1 in the mixed bottom and reef flat. Among the chaetodontids, *C.auriga* was the most abundant species. The distribution of *C.lunula, C.xanthocephalus, C.citrinellus, C.kleini* and *C.falcula* was relatively equal in the coral bed habitat. The numerical abundance of *C.citrinellus, C.kleini C.falcula, C.melannotus* and *C.trifasciatus* remained relatively constant in the mixed bottom and reef flat habitats, but a wide variation was noticed in the abundance of *C.falcula* in the coral bed habitat from the other two habitats. *C.trifascialis* was present only in the coral bed habitat.

2.4.4. FAMILY APOGONIDAE

The five species of apogonids were observed in the coral bed and mixed bottom habitats throughout the entire period of study. The number of apogonids was not counted considering their nocturnal habits.

2.4.5. FAMILY ACANTHURIDAE

A different pattern in distribution and abundance of the four acanthurid fishes, *A.triostegus, A.leucosternon, A.lineatus* and *P.hepatus* was noticed in the three different habitats. There observed not much variation in the abundance of *A.triostegus* between the three habitats, the range in number being 80 - 128 in the coral bed, 76 - 120 in the mixed bottom and 75 - 120 in the reef flat. *A.leucosternon* was most abundant in the coral bed, their average number being 11 and was only frequently observable in the mixed bottom with an average number of 3 and found occassionally in the reef flat area, where the average number was 1. *A.lineatus* was continuously observed in the coral bottom, frequently in the reef flat area but was not seen in the mixed bottom during the entire period of study. 4 - 8 *P.hepatus* were observed in the coral bottom , and 2 - 3 in the mixed bottom and were not noted in the reef flat area. In the mixed bottom, a pair of *P.hepatus* was found to be residing permanently on the same coral throughout the study period.

2.4.6. FAMILY SCARIDAE

These fishes were frequently observed in the coral bed. Only two species namely *S.bataviensis* and *S.ghobban* were found in the mixed bottom and in the reef flat, scarids were not encountered. More scarids were noticed in the coral bed habitat.

2.4.7. FAMILY SCORPAENIDAE

P.antennata, P.volitans and *P.radiata* were found frequently in the three habitats and there was not much variation in their number between the three habitats.

2.4.8. FAMILY POMACANTHIDAE

These fishes were continuously observed in the coral bed and mixed bottom habitats. The average number of *C.multispinis* observed in the coral bed was 10 and that of *P.imperator* was 3. In the mixed bottom the number of *C.multispinis* was 9 and that of *P.imperator* was 2. Both *C.multispinis* and *P.imperator* were observed only occassionally in the reef flat area and their average number noticed was 1.

2.4.9. FAMILY HOLOCENTRIDAE

H.sammara and *S.diadema* were found frequently in the coral bed, occassionally in the mixed bottom and reef flat habitats and were in more numbers in the coral bed habitats.

2.4.10. FAMILY ZANCLIDAE

Z.canescens was observed in pairs in the three habitats frequently. The number was varying between 1 - 4 pairs in the coral bed, 1 - 3 pairs in the mixed bottom and 1 - 2 pairs in the reef flat area.

2.4.11. FAMILY CANTHIGASTERIDAE

The highest range in the number of *C.margaritatus* was observed in the coral bottom. In the mixed bottom it was 3 - 5 and in the reef flat area 4 - 7.

2.4.12. FAMILY OSTRACIDAE

O.cubicus was frequently observed in the three habitats. Its number was 0 - 5 in coral bed and 0 - 3 in the other two habitats.

2.4.13. FAMILY CIRRHITIDAE

P.forsteri was not observed in the reef flat area. The range in number was 2 - 6 in coral bed and 2 - 4 in mixed bottom.

2.4.14. FAMILY BALISTIDAE

R.aculeatus was continuously observed in the three habitats. Its average number was 11, 9 and 5 in the coral, mixed bottom and reef flat habitats respectively.

2.4.15. FAMILY LUTJANIDAE

L.kashmira was not observed in the reef flat area. The fish showed a preference to the coral bed, where its range in number was found to be 8 - 14, with an average of 11. In the mixed bottom habitat its number varied between 2 and 8, the averege being 5.

2.4.16. FAMILY PLATACIDAE

P.orbicularis was not observed in the mixed bottom. In the reef flat area the fish was frequently observed but were occassional in the coral bed. In both these habitats, this fish was found in small shoals.

2.4.17. DISTRIBUTION OF ENVIRONMENTAL PARAMETERS

Since there existed a remarkable difference in the distribution and abundance of the various ornamental fishes in the five habitats in the Minicoy lagoon, the hydrographic parameters namely temperature, dissolved oxygen, salinity, phosphate, silicate, nitrate, nitrite and zooplankters in these five habitats were analysed to study their relationship, if any , with the distribution and abundance of ornamental fishes and thereby to understand the factors determining the distribution and abundance of ornamental fishes in the lagoon environment. The results of these analyses are as follows:-

2.4.17.1. TEMPERATURE Pl. 24

The distribution of water temperature in the five habitats is given Pl. 24. Monthly variation of temperature in the coral bed and mixed bottom was observed to be between 27.8^{0} and $30.5^{0}C$. The range of temperature in the other habitats was as follows: Reef flat - 27.9^{0} - $30.5^{0}C$ sand bed - 27.5^{0} - $30.5^{0}C$ and seagrass bed 26.9^{0} - $32^{0}C$. Eventhough there were variations in temperature in different months in different habitats, it was observed that there was only very little variation in the distribution of temperature between different habitats in the same month, with a few exceptions in the seagrass habitat.

2.4.17.2. DISSOLVED OXYGEN Pl. 24

The range in the distribution of dissolved oxygen in the different habitats was given by : coral bed - 4.41 - 5.65 ml/l, reef flat - 4.29 - 5.42 ml/l, sand bed 4.29 - 5.32 ml/l, seagrass bed - 3.28 - 5.76 ml/l and mixed bottom 4.41 - 6.78 ml/l. It was observed that the range in distribution of dissolved oxygen in the five habitat was very narrow in each month with the exception in November 1988 in coral bed, July, August and September, 1989 in seagrass bed.

2.4.17.3. SALINITY Pl. 24

The range in the distribution of salinity in the five habitats was as follows : coral bed 34.02 - 35.4 ppt reef flat - 34.01 - 35.53 ppt, mixed bottom - 34.02 - 35.67 ppt, seagrass bed - 34.02 - 35.31 ppt and mixed bottom 34 - 35.34 ppt. It was observed that the distribution of salinity in the five stations did not show much variation in the same month.

2.4.17.4 PHOSPHATE Pl. 25

The lowest value of phosphate observed in all the five habitats was 0.03 µ gm at/litre. The highest value of 2.18 was observed in seagrass bed followed by 1.68 in coral bed, 1.32 in sand bed, 1.28 in reef flat bed and 1.05 μ gm at/l in the mixed bottom. In the same month there was not much variation in the phsophate content in the five stations.

2.4.17.5 SILICATE Pl. 25

The distribution of silicate in the five stations was as follows: coral bed 2.1 - 5.7, reef flat 1.9 - 4.6, sand bed - 2.3 - 5.7, seagrass bed 2.2 - 7.35 and mixed bottom 2.1 - 6.45 μ gm at/l. With a few exceptions, the value of silicate content did not vary much between the five habitats in the same month.

2.4.17.6. NITRATE Pl. 26

The lowest value of nitrate in all the five habitats was 0.01 μ gm at/l and the highest values observed in different habitats were as follows: coral bed 0.8, reef flat 1, sand bed 1.15, seagrass bed 1.2, and mixed bottom 1.1 μ gm at/l. It was observed that, with a few exceptions the same monthly values of nitrate content remained almost the same in the five habitats.

2.4.17.7 NITRITE Pl. 26

The lowest value of nitrite observed in the five habitats was 0.01 μ gm at/l. The highest values in the different habitats were : coral bed - 0.65, reef flat - 0.53, sand bed - 0.66, seagrass bed - 0.78 and mixed bottom

- 0.70 μ gm at/l. The nitrite values in the different habitats in any given month did not show much variation.

2.4.17.8. ZOOPLANKTON Pl. 27

Plate 27 shows that the volume of zooplankton did not vary much between different habitats in different months, except in the reef flat and coral bed habitats. The highest volume of zooplankton observed was 7.9 ml/l in the coral bed habitat. Among the five habitats the volume of zooplankton observed was higher in the coral bed and reef flat habitats and comparitively low values were observed in the seagrass bed and mixed bottom habitats. Most of the monthly values of zooplankton volume in all the five habits were distributed below 0.4 ml/l. Tables 2.4, 2.5, 2.6, 2.7 and 2.8 give monthly percentage of each zooplankton in the five habitats. A total of 40 different zooplanktons were observed in reef flat area, followed by 36 in the mixed bottom, 35 in coral bed, 32 in seagrass bed and 31 in the sand bed habitat. Among the various zooplanktons, copepods were observed to be the dominating item in the five habitats and was observed almost continuously in all the habitats. All the other items were observed to be occuring irregularly in different months.

No correlation was observed between the distribution and abundance of fishes and the hydrography and zooplankton. It was observed that there was only a narrow range in the distribution of values of temperature , DO_2, salinity, PO_4, SiO_3, NO_3, NO_2 and the volume of zooplankton in the five habitats with a few exceptions. Eventhough the

TABLE: 2.4. PERCENTAGE VOLUME OF VARIOUS ZOOPLANKTON IN THE CORAL BED HABITAT IN THE MINICOY LAGOON DURING 1988 - 1990

Sl. No	Zooplankton	Year.	Month Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Fish larvae	88-89	0.4	0.34				0.05	0.05	0.28				0.08
		89-90	0.35	0.28	0.58	0.46				0.07		0.05	0.12	0.15
2	Fish eggs	88-89	13	4	0.8	5.2	32.32	1.28	22.3	1.18	0.76	27.78	0.8	0.3
		89-90	10.03	1.05	5.22	2.32	5.27	37.5	0.23	0.2	8.41	0.49	1.95	0.14
3	*Doliolm*	88-89		0.17										
		89-90	0.28		1.93									
4	*Salpa*	88-89	0.2	0.97		1.35								0.03
		89-90					1.28			0.03				
5	Brittle star	88-89											1.3	
		89-90												
6	Bivalves	88-89			4.3			2.16					3.9	
		89-90												
7	Bivalve larvae	88-89					0.38							
		89-90			0.2									
8	*Dentalium*	88-89												0.03
		89-90					0.03						0.06	
9	Other	88-89	0.2	1.71		0.16			0.49				3.4	1.48
	gastropods	89-90	0.14	2.16		1.08	0.13		1.92	0.61	0.93	0.02	11.04	27.43
10	*Sepia*	88-89												
		89-90	0.07											

Contd....

1	2	3	4	5	6	7	8	9	10	11	12	13	14	
24	Copepods	88-89	30.3	29.67	31.05	43.48	20.63	20.94	21.63	71.1	6.06	11.11	29.15	37.02
		89-90	8.85		37.26	53.52	43.56	41.66	6.25	7.98	8.41	0.91	11.77	48.82
25	Ostracods	88-89				7.34			0.02					
		89-90				0.56	7.26					0.02	0.06	
26	*Sapphrina*	88-89		0.34		2.79	0.5							0.1
		89-90	0.07				2.72							
27	*Tomopteris*	88-89												
		89-90					0.07							
28	Other	88-89			2.2				0.05				2.1	
	Polychaetes	89-90					0.2				0.93	0.02		
29	Chaetognaths	88-89	3.5	6.17	0.52	4.83			10.6	0.7	0.76			0.44
		89-90	1.9			2.6	4.83			0.1			0.3	0.12
30	Appendicularia	88-89	3	11.74	5.6	1.28	11.82						5.7	0.1
		89-90	1.11				1.28						4.82	
31	Siphonophores	88-89	2	5.16	1.53	24.76	17.99		24.31	0.07			1.03	1.64
		89-90	0.83	13	27.66	25.96	24.76		0.11					
32	Ephyra Larva	88-89												
		89-90								0.03				
33	Medusae	88-89								0.07			1.55	0.03
		89-90								0.1				
34	Hydroidpieces	88-89											0.52	
		89-90												
35	Foraminifera	88-89	0.4	0.56		0.35			0.02					
		89-90					0.17			0.1	4.7			0.24
		88-89	100	100	100	100	100	100	100	100	100	100	100	100
		89-90	100	100	100	100	100	100	100	100	100	100	100	100

TABLE: 2.5. PERCENTAGE VOLUME OF VARIOUS ZOOPLANKTON IN THE REEF FLAT IN THE MINICOY LAGOON DURING 1988 - 1990

Sl. No	Zooplankton	Year	Month											
			Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Fish larvae	88-89			6.4		0.03		0.16	0.35	0.4	0.06	0.14	0.56
		89-90	0.34							0.18	0.6	0.13		0.34
2	Fish eggs	88-89	7.62		6.38	14.78		26.34		23.6	13	36	63.54	1.7
		89-90	4.97				1.13	31.44	15.23	23.59	2.7	7.5	3.07	1.11
3	*Doliolm*	88-89								0.48	0.2	1.66	0.34	
		89-90	1.17		5	2.3	0.08	0.88		0.18	1.15	0.95	0.94	0.25
4	*Salpa*	88-89					0.56						0.66	0.56
		89-90				1.8	3.88			0.04	1.14		0.11	
5	Bipinnaria	88-89												
	larva	89-90									1.03		0.05	
6	*Pecten*	88-89												2.26
		89-90	0.17											
7	Other bivalves	88-89	0.93					0.21					0.06	
		89-90									0.02		0.03	
8	Bivalve larva	88-89	0.26				2.11							
		89-90					0.08	0.38						
9	*Dentalium*	88-89		0.03		0.12			0.01			0.77	0.14	
		89-90	0.17				0.08			3.09	0.11		0.25	0.03
10	Pteropods	88-89												
		89-90		10								0.1	0.03	0.18
11	Other gastropods	88-89		7.6			6.81		12.34			1.24	0.46	6.5
		89-90	1.37	10		3.78			0.84	1.42	0.99		5.18	32.53
12	*Sepia*	88-89												
		89-90									0.02			

Contd...

1	2	3	4	5	6	7	8	9	10	11	12	13	14	16
13	*Fungia*	88-89												
		89-90												0.01
14	Gastropod larvae	88-89		2.1		3.2		0.98			0.2			
		89-90					0.08	0.38						
15	Cypris stage	88-89												
	of Balanus sp.	89-90									0.02			
16	*Lucifer*	88-89		16.26	1.87		12.14		0.96		0.1			
		89-90	0.7				0.08				1.87	2.77	37.8	10.24
17	Decapods	88-89	0.79			14.2			26.8	0.98				
		89-90					0.08				5.71	0.03	0.11	0.06
18	Zoea	88-89		17.8	16.3		28.61		2.78	8.5	10	0.06	0.72	10.45
		89-90	2.92			4.62		4.53	16.91	11.11	0.88	4.67	5.18	2.26
19	Alima larvae	88-89		0.03				0.56	0.02		1.1			
		89-90							0.14	0.4		17.7	0.08	0.04
20	Nauplii	88-89												1.72
		89-90					0.08			0.09	0.7	0.16	0.08	0.04
21	Megalopa	88-89												
		89-90							0.28		0.24		0.05	0.37
22	Other decapod	88-89	23.6	4.31	7.53	41.7	12.6	16.8	0.91	6.35	11	1.48	2.38	12.71
	larvae	89-90	1.54			4.3	1.21	11.07	59.33	42.32	3	21.55	17.7	16.86
23	Stomatopod	88-89												
	larvae	89-90						0.38						
24	Mysids	88-89		1.8	0.9	8.7			3.2		21.8			
		89-90	24.01						0.07					
25	Amphipods	88-89			2.6		0.96	5.2	1.2			0.18		0.28
		89-90			15	0.35	0.49	0.13	0.21	0.04	0.36		0.05	
26	Isopods	88-89		12.1		3.4		0.91					0.03	
		89-90				0.31								

Contd....

1	2	3	4	6	6	7	8	9	10	11	12	13	14	16
27	copepods	88-89	18.96	32.42	26.81	12.34	52.12	20.96	48.36	36.69	33.2	31.79	14.98	22.32
		89-90	29.67	14.29	40	45.11	44.71	20.5	6.64	7.26	48.05	21.87	9.54	31.49
28	Ostracods	88-89			0.21		1.86		0.35					
		89-90									0.13		0.03	
29	*Sapphrina*	88-89	18.72	0.41		2.78			10.4	0.76		0.88	2.21	
		89-90	0.34			0.28	1.7	0.5			0.17	0.41	0.08	
30	*Tomopteris*	88-89												
		89-90									0.17		0.03	
31	Other polyc-hates	88-89		0.08		0.16		1.24				0.18	0.14	
		89-90	0.56							0.04	0.02	0.03	0.05	0.04
32	Polychaete larvae	88-89	0.78			1.68					0.1			
		89-90												
33	Invertebrate egg mass	88-89												
		89-90									3.39	0.73	0.6	0.01
34	chaetognaths	88-89			22.8		2.18		1.6	2.5	3.4	0.71	0.89	15.54
		89-90	6.17			5.6	8.4	3.9	0.07	0.35	10.53	5.94	3.87	2.3
35	Appendicularia	88-89		4.6					16.73	8.5	0.1	9.41	0.86	20.06
		89-90	14.07		10		0.57	7.92		7.44	4.68	2.67	0.74	0.1
36	Siphonophores	88-89	28.34	0.16			9.99			12.32	2	13.56	10.1	6.5
		89-90	11.33	85.71	10	30.6	35.49	17.99	0.28	2.26	8.86	12.78	13.55	1.73
37	Medusae	88-89									0.4	2.01	2.35	
		89-90	0.34			0.96	1.86			0.06	0.17		0.63	0.01
38	Hydroid pieces	88-89												
		89-90									0.11			
39	Radiolaria	88-89		0.12										
		89-90											0.14	
40	Forminifera	88-89		0.18			1.15	0.02						
		89-90									0.13	3.18	0.03	
		88-89	100	100	100	100	100	100	100	100	100	100	100	100
		89-90	100	100	100	100	100	100	100	100	100	100	100	100

TABLE: 2.6. PERCENTAGE VOLUME OF VARIOUS ZOOPLANKTON IN THE MIXED BOTTOM IN THE MINICOY LAGOON DURING 1988 - 1990

Sl. No	**Zooplankton**	**Year**	**Month**											
			Apr.	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Fish larvae	88-89		0.04	0.05		0.91							
		89-90								0.11	26.53			0.44
2	Fish eggs	88-89	1.94	17.78	0.78		8.91		23.56	15.36	12.67	14.7	42.47	5.53
		89-90	28	26	2.13			1.6	14.51	12.57			0.6	1.21
3	*Doliolum*	88-89				0.36				0.56			0.67	
		89-90				0.96	0.85	0.28		0.34		1.21	0.15	0.77
4	*Salpa*	88-89	0.03		0.08								0.67	
		89-90			0.58	0.26	0.28	0.34		0.11		0.16	0.05	
5	*Pecten*	88-89										2.94		
		89-90												
6	Other bivalves	88-89	0.05		0.89							29.41	0.33	
		89-90					0.11				4.08			
7	Bivalve larvae	88-89	1.26		1.26				11.12					
		89-90							0.09					
8	*Dentalium*	88-89		0.01				0.03						
		89-90					0.09	0.11		2.5		0.4	0.05	
9	Pteropods	88-89					0.01							
		89-90					0.12							

Contd...

1	2	3	4	5	6	7	8	9	10	11	12	13	14	16
10	Other	88-89	0.06					4.46	2.3	1.63	1	2.94	1.35	2.51
	gastropods	89-90	2	4	2.5			0.43	0.62	0.68	8.17		1.93	11.23
11	*Fungia*	88-89												
		89-90											0.15	
12	Gastropod	88-89	1.84		8.31	7.21			5.6					
	larvae	89-90										0.24		0.11
13	*Lucifer*	88-89		21.98					11.85					
		89-90	20	22.5	3.1	7.6	0.83	1.78		0.23	4.08	1.45	64.29	31.5
14	Decapods	88-89												
		89-90												27.31
15	Zoea	88-89	2.67	15.36		13.98	14.95	36.21	7.92	4.26	2.16		2.05	11.56
		89-90	2	1.5	0.89		1.23	5.83	14.07	14.72	6.12	4.11	3.59	
16	Alima larvae	88-89												
		89-90			0.63			0.28		0.34		7.82	0.1	
17	Nauplii	88-89												
		89-90			0.23					0.18	0.56	0.24	0.1	
18	Megalopa	88-89												
		89-90						0.3	0.27					
19	Phyllosoma	88-89												
		89-90								0.11				
20	Other decapod	88-89	11.64	12.36	31.24	25.67	36.28	7.94	26.33	38.89	46.11	26.47	4.01	13.57
	larvae	89-90	2	13.2	54.24	53.68	48.16	46.16	58.15	52.22	20.41	24.19	15.64	0.55
21	Mysids	88-89												
		89-90									2.04			
22	Amphipods	88-89												0.5
		89-90			0.12				0.09	0.11				
23	Isopods	88-89											6.7	0.5
		89-90			0.48					0.56		0.08	0.15	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24	Cumaceans	88-89				10.01		6.21						0.5
		89-90												
25	Copepods	88-89	61.63	28.95	53.26	25.31	18.99	27.21	19.26	23.11	31.2	20.6	30.1	39.2
		89-90	18	21.16	19.1	22.32	18.92	24.61	10.42	8.61	18.37	27.75	6.72	21.6
26	Ostracods	88-89						5.26						
		89-90											0.05	
27	*Sapphrina*	88-89	0.89			0.9	9.87	2.26	0.98				4.01	1
		89-90					3.12	0.68	0.8	0.57		2.74		
28	Polychaetes	88-89	1.6		3.1	0.82	0.6		2.1			2.94		
		89-90	4				0.13	1.3		0.34		0.08	0.15	
29	Polychaete	88-89				1.06								
	larvae	89-90									6.12			
30	Invertebrate	88-89												
	egg mass	89-90									0.11		2.26	0.1
31	Chaetognaths	88-89	8.72	2.8		5.36	0.95		0.83				1	4.02
		89-90	6				3.85	2.6		0.45		7.18	2	1.52
32	Appendicularia	88-89	0.89			0.03	1.71	3.91	9.28	0.89				
		89-90	2		1.8		1.36	0.58		1.36		1.53	0.25	
33	Siphonophores	88-89	6.78	0.72		8.67	5.53			15.3	6.86		6.69	21.11
		89-90	16	11.64	14.2	15.18	20.17	3.08	0.71	2.27		18	3.78	1.54
34	Medusae	88-89												
		89-90								0.11		0.16		
35	Radiolaria	88-89												
		89-90					0.18	0.28		0.34				
36	Foraminifera	88-89						0.21						
		89-90					0.34	0.06	0.09	0.68	4.08	0.24	0.15	
		88-89	100	100	100	100	100	100	100	100	100	100	100	100
		89-90	100	100	100	100	100	100	100	100	100	100	100	100

TABLE: 2.7. PERCENTAGE VOLUME OF VARIOUS ZOOPLANKTON IN THE SAND BED IN THE MINICOY LAGOON DURING 1988 - 1990

Sl. No	Zooplankton	Year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Fish larvae	88-89		0.5					0.3					
		89-90		1.3					0.12					0.8
2	Fish eggs	88-89	2.6			2.5	8.3		7.8		2.3			
		89-90	22.3		1.25	12.8				14.6		2.6		
3	*Doliolum*	88-89				2.12							1.63	
		89-90				5.2								
4	*Salpa*	88-89					3.2	7.3			0.85			
		89-90		1.25					0.68				2.5	
5	Brittle star	88-89				0.2					0.05			
		89-90					0.8							
6	Bivalves	88-89		1.2					2.3					
		89-90	1.61					3.52						1.22
7	Bivalve larvae	88-89				0.86					0.54			
		89-90		0.26								0.84		
8	Pteropods	88-89			0.22									
		89-90				0.08								
9	Other gastr-opods	88-89		1.68					25.6		17.21		12.6	
		89-90					13.4			20.8		7.65	5.6	11.64
10	Gastropod larvae	88-89				0.62					1.08			
		89-90		2.02	25.6					1.24	38.5			
11	*Lucifer*	88-89			6.5		5.65			1.85			28.5	
		89-90	12.65					8.65				12.33		35.68
12	Other Decapods	88-89		15.85			26.2		2.14			14.8		
		89-90				5.99			13.25				28.5	
13	Zoea	88-89		7.35				12.85						26.5
		89-90			13.35				8.25		3.25		5.35	
14	Alima larvae	88-89		0.2						0.16				
		89-90		28.65		0.08							0.31	
15	Nauplii	88-89				0.71						0.28		

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	Other decapod	88-89	12.75	6.82	35.65		26.8		3.85		7.85			
	larvae	89-90	42.35		36.15		26.3		14.35		25.15	2.68		0.95
17	Mysids	88-89		1.8		26.3				10.35			18.35	
		89-90				12.68			36.15		5.85			
18	Amphipods	88-89				3.81				44.25				15.65
		89-90						34.18					7.85	
19	Isopods	88-89						7.6	25.6			24.5		
		89-90		3.76		31.85					2.78	15.65		8.05
20	Copepods	88-89	1.85	32.63	8.95	12.63	28.65	26.35	27.18	8.15	41.76	17.15	32.62	41.31
		89-90	1.36	8.18	9.15	31.26	29.15	36.14	12.63	56.14	7.89	3.65	36.75	40.85
21	Ostracods	88-89		0.82				3.2				26.16		
		89-90	5.78		2.6		5.75		0.96			26.5		
22	Cumaceans	88-89	36.16			5.53			5.23			17.11		
		89-90			8		13.14					5.75		
23	*Sapphrina*	88-89			23.41		1.18			5.23				
		89-90	3.3		6.5				13.61					
24	*Tomopteris*	88-89						0.06						
		89-90					0.12							0.81
25	Other Polychaetes	88-89				12.62								
		89-90												
26	Polychaete	88-89						7.36						
	larvae	89-90						1.65						
27	Chaetognaths	88-89	42.15		21.32	32.1				3.66			6.3	
		89-90	10.65				11.34				19.15		6.35	
28	Appendicularia	88-89		31.17				34.36						14.2
		89-90		15.48						7.22			2.52	
29	Siphonophores	88-89	4.49		3.95			0.92		26.35	27.52			2.34
		89-90		36.5				15.51			0.68	19.1	4.27	
30	Radiolaria	88-89									0.21			
		89-90				0.06								
31	Foraminifera	88-89					0.02				0.63			
		89-90												
		88-89	100	100	100	100	100	100	100	100	100	100	100	100
		89-90	100	100	100	100	100	100	100	100	100	100	100	100

TABLE: 2.8. PERCENTAGE VOLUME OF VARIOUS ZOOPLANKTON IN THE SEAGRASS BED IN THE MINICOY LAGOON DURING 1988 - 1990

Sl. No	Zooplankton	Year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
			Month											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Fish larvae	88-89					0.16							
		89-90												
2	Fish eggs	88-89		25	18				2.6		15.31			36.5
		89-90				1.67		25.5		15.6				8.5
3	*Doliolum*	88-89								8.64				
		89-90				2.8								
4	*Salpa*	88-89			26								5.5	
		89-90							1.6					
5	Brittle star	88-89							0.02					
		89-90					0.16							0.01
6	Bivalves	88-89					7.8					1.22		0.89
		89-90			2.68					1.42		7.91		
7	Bivalve larvae	88-89							9.6			2.1		0.24
		89-90		0.8		0.01		1.12				0.06		
8	*Dentalium*	88-89					0.02							0.06
		89-90						0.01				0.01		
9	Pteropods	88-89							7					
		89-90												
10	Other gastropods	88-89	1.32						8.6		1.81	18.96		12.14
		89-90			26.4					3.2		30.8		
11	Gastropod larvae	88-89	10.3							0.02				0.86
		89-90					0.03							
12	*Lucifer*	88-89							3.2			1.2	8.5	
		89-90			3.8				16.16			0.98		
13	Other Decapods	88-89												
		89-90				20.5								28.7
14	Zoea	88-89	38.52	25		7.2					12.8		40.5	
		89-90			6.32					3.58		32.6		
15	Alima larvae	88-89	0.26											
		89-90						1.2						

Contd...

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
15	Alima larvae	88-89	0.26											
		89-90						1.2						
16	Nauplii	88-89												
		89-90						5.6		1.2				
17	Other decapod	88-89	45.65					12.68						24.41
	larvae	89-90	63.5				36.28		41.2		1.6			
18	Mysids	88-89					6.7					1.36		
		89-90			0.86			32.6					11.7	
19	Amphipods	88-89							7.8					
		89-90	9.21						0.86	51.66		0.02		
20	Isopods	88-89			2				2.1	12.8				0.12
		89-90				3.6				12.81	25.8			16.5
21	Copepods	88-89	1.58	50	10	32.6	4.69	12.11	45.36	40.68	28.18	18.36	3.95	54.6
		89-90	1.68	38.19	42.6	68.16	52.34	28.05	18.16	7.63	4.89	12.6	23.4	25.85
22	Ostracods	88-89	2.11				28.91							
		89-90		26.2			3.6						35.6	
23	Cumaceans	88-89				0.9		46.91			5.6			
		89-90		6.51				4.32					28.5	
24	*Sapphrina*	88-89					2.38		8.96					
		89-90		28.3			2.71							
25	*Tomopteris*	88-89						1.11						
		89-90												
26	Other Polychaetes	88-89							7.8				5	
		89-90												
27	Polychaete	88-89							3.96		12.8			
	larvae	89-90			1.74					2.4				0.04
28	Chaetognaths	88-89			2	42.78		3.6			23.5			6.2
		89-90						1.6			39.21		0.8	
29	Appendicularia	88-89						23.6		0.18		56.8		0.48
		89-90			15.6	3.26						15.02		
30	Siphonophores	88-89			42	16.36	49.5			30.68				
		89-90				5.88		22.02		28.5				20.6
31	Radiolaria	88-89	0.26											
		89-90								0.5				
32	Foraminifera	88-89											0.05	
		89-90												
		88-89	100	100	100	100	100	100	100	100	100	100	100	100
		89-90	100	100	100	100	100	100	100	100	100	100	100	100

various ecological conditions were almost same in all the habitats, only negligible number of ornamental fishes were observed in the sand bed and no ornamental fishes were observed in the seagrass bed throughout the entire period of study.

The fishes showed a clear affinity towards corals, either dead or alive. In the atolls of Lakshadweep it was common that the distribution and abundance of ornamental fishes depended on the distribution and abundance of corals in the lagoon. Wherever corals were available, some ornamental fishes were invariably seen associated with them and these fishes were not found in the sand and seagrass bed habitats. The observation in the lagoon also revealed a gradual disappearence of the ornamental fishes from areas which were primarily occupied by corals, but invaded by seagrass secondarily.

The present study showed that the distribution and abundance of ornamental fishes were less in the reef flat and mixed bottom habitats, when compared to that in the coral bed habitat. These two areas were subjected to high wave actions and during low tides, a good part of the reef flat area becomes exposed (Pl. 28), thereby forcing the resident fishes to migrate to the deeper areas. In the lagoon, *A.leucosternon* was found associated with the coral, *Acropora formosa* in the deeper regions in large numbers, but observed only occassionally in the shallower, near reef region. When observed in these areas, they were seen as single or pair, but never in groups.

2.5. DISCUSSION

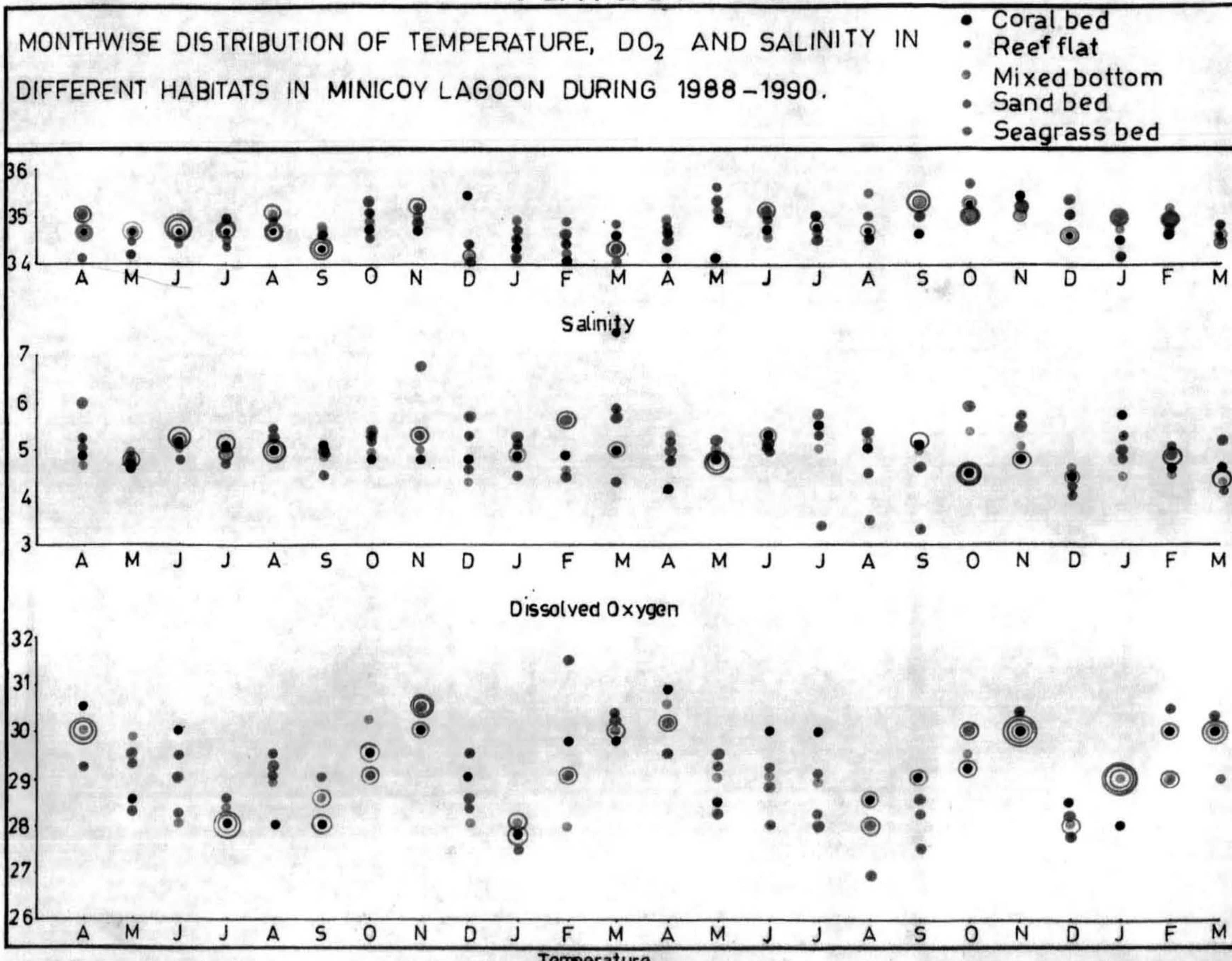
The term "Coral reef fish" implies a close association between corals and fishes. The reef fishes depend on corals for shelter and food. Many of them feed on reef invertebrates, such as sponges, corals, tunicates, seaurchins and snails. This type of predator-prey relationship may postulate the concept of co-evolution of corals and coral reef fishes (Birkland 1977, Brock 1979, Lobel 1980, Ogden 1976, Ogden and Lobel 1978, Reese 1981). According to Cadoret *et al.*(1995), among the macrobenthic groups namely, corals , algae, molluscs, echinoderms and sponges, corals were found to be the most important factor affecting the spatial distribution of butterfly fishes. Although many fish species use coral interstices for shelter and feeding sites, there are only three known genera of obligate coral dwelling fishes; three from family Gobiidae (*Paragobiodon echinocephalus, P.lacunicola, P.xanthosoma* and *Paragobiodon* sp.) and one from Caracanthidae (*Caracanthus* sp.)(Lassig 1977). Many species of reef fishes occur also in habitats other than coral reefs, and in regions outside the geographic range of reef building corals (Sale 1980). Hence the general conclusion drawn from the present study is that the direct association of certain fishes with the corals is for shelter and food. The strongly site - attached nature of the small pomacentrid fishes in groups indicates and adaptation to predation on the fishes, as the predators are most likely to select individuals that stand out from the rest of the school in their physical appearence or behaviour (Hobson 1968, 1976). The damselfishes showed significant preference for coral heads with complex internal structure as evident in plate 29. Ebersole (1985) also made the same findings. Liberman *et al.* (1995) demonstrated that the association between *Dascyllus marginatus* and its host coral is mutualistic. The parrot fishes, wrasses, groupers, snappers and grunts are suprabenthic and eventhough they are associated with the substratum, they are not confined to small home ranges or to particular shelter sites and move easily from one patch reef to another (Smith and Tyler 1973b). Butterfly fishes, with one or two exceptions are not territorial, but they seek hiding places at night (Ehrlich *et al.* 1977). According to Luckhurst and Luckhurst (1978) also, availability of shelters for the fish is an important factor. Findley and Findley (1985) find species richness and individual abundance of butterfly fishes increase with coral density. Robertosn *et al.*(1979) reported the territorial behaviour of *Acanthurus lineatus* and *A.leucosternon.*

The typical reef fishes are strongly site attached (Sale, 1982) and the frequent changes in the water column may be of adverse nature to this characteristic of the reef fishes. Sale (1977, 1978) also reported that small species confine to a single coral colony. This may be the reason why the small, sedentary pomacentrid fishes kept away from the actual reef flat area, which is subjected to tidal fluctuations. The bigger species such as labrids moved in all areas (Ogden and Buckman 1973, Robertson and Choat 1974, Goeden 1978, Sale 1978) and this explains their distribution in the three habitats. The pattern of disperson of a population reflects a species response to its environment and thus has important ecological consequences (Suttan 1985). Coral reefs are unpredictable and heterogeneous environment in the extreme (Bardach 1958, Springer and Mc Erlean 1962, Thompson and Munro 1978). The numerous qualities of coral reef habitats, which along or in combination might directly affect the ability of a fish to survive there, such as coral species composition, topographic complexity, current structure, depth, wave action, light penetration, predation intensity etc. are distinct and predictable only on the larger scale of broadly defined reef habitats (Alevizon *et al.* 1985). Individuals of the same species often display differences in spacing pattern under different environmental circumstances (Findley and Findley 1985). It was observed that the species composition and the abundance of the fishes remained more or less constant in the deeper regions of the lagoonal coral patches. Ogden and Buckman (!973) reported the feeding migration of reef fishes especially herbivores, inorder to feed at high tide shallow regions, inaccessible during low tide. Feeding and spawning by *Acanthurus nigrofuscus* upto 1.5 km in the nortern Red Sea has been reported by Mazeroll and Montgomery (1985). However Alevizon *et al.* (1985) emphasized the dominating influence of coral zonation *per se*, as opposed to depth, both on fish community structure and the individual distribution and abundance patterns of most of the larger reef fishes. The influemnce of depth is subordinate to other aspects of habitat structure in determining the structure of reef fish communities. Green *et al.* (1987) emphasized the importance of depth as a physical determinant of local taxon abundances. Mc Cormick (1994) was of the opinion that topography was only secondary in importance to depth in describing the patterns of damsel fish abundance. Bouchon - Navaro (1979) observed that the different size - classes of chaetodons inhabited different reef zones. Fowler (1991) also observed significant differences in the abundance of chaetodons in the different localites at the One Tree Reef, southern GBR. Juveniles and sub - adults were generally more abundant in shallow - water areas whether it be coral reefs or seagrass beds, whereas adults predominated in deeper waters (Fricke 1973, Clarke 1977, Bouchon - Navaro 1979, 1981, Lindquist and Gilligan 1986).

The study on the pattern in the distribution of fish communities across the central Great Barrier Reef conducted by Williams (1982) showed differences in the composition of assemblages among replicate censuses within individual reefs and also differences between reefs at the same location on the transect. According to him, the distribution and abundance of species of coral reef fish appears to be strongly influenced directly or indirectly by physical factors such as wave exposure, sediment loads, water depth and topographical complexity as well as biological factors. A similiar study conducted by Gladfelter *et al.* (1980) in the Virgin and Marshall islands showed a positive correlation of the fish species diversity with reef surface complexity, projected reef surface area and reef height. Mc Gehee (1994) observed that fish assembleges were most numerous in the back reef of Puerto Rico,where water motion, slope inclination and substrate sizes were minimal. This study also underlines the effect of environmental factors such as the oceanic influence on the species diversity in the reef ecosystem.

The high diversity of coral reef fish communities includes a large within habitat component (Goldman and Talbot 1976) wherein large members of species may co-occur in a very small space (Smith and Tyler 1972). It has been suggested by Sale (1977, 1978) that the mechanism of maintaining such great diversity may depend to a relatively large degree on the chance arrival of propagules at a particular site as well as the unpredictable production of habitable space, rather than on more deterministic factors such as habitat structure or biological factors such as fine partitioning of food or space resources or specific predator - prey relationships. Forrester (1990) also opinioned that both recruitment and post recruitment processes influence patterns in abundance in *D.aruanus*. Smith (1978) had emphasized the importance of adaptive responses to compeitition or predation in structuring these communities. Two extreme views have dominated debate on the structure of coral reef communities. The "law and order view" sees reefs as ordered systems in which biotic (Sheppard 1982) and physical (Bradbury and Young 1981) factors largely control population distributions and abundances. The alternative "anarchy view" sees them as systems that are so complex, that attempts to model them detect only chaos (Sale 1980, Schaffer 1985, Ulanowicz 1979, Vandermear 1982).

PLATE 24



MONTHWISE DISTRIBUTION OF TEMPERATURE, DO_2 AND SALINITY IN DIFFERENT HABITATS IN MINICOY LAGOON DURING 1988-1990.
Coral bed
Reef flat
Mixed bottom
Sand bed
Seagrass bed
ppt
36
35
34
A M J J A S O N D J F M A M J J A S O N D J F M
Salinity
ml/l
7
6
5
4
3
A M J J A S O N D J F M A M J J A S O N D J F M
Dissolved Oxygen
°C
32
31
30
29
28
27
26
A M J J A S O N D J F M A M J J A S O N D J F M
Temperature

PLATE 25

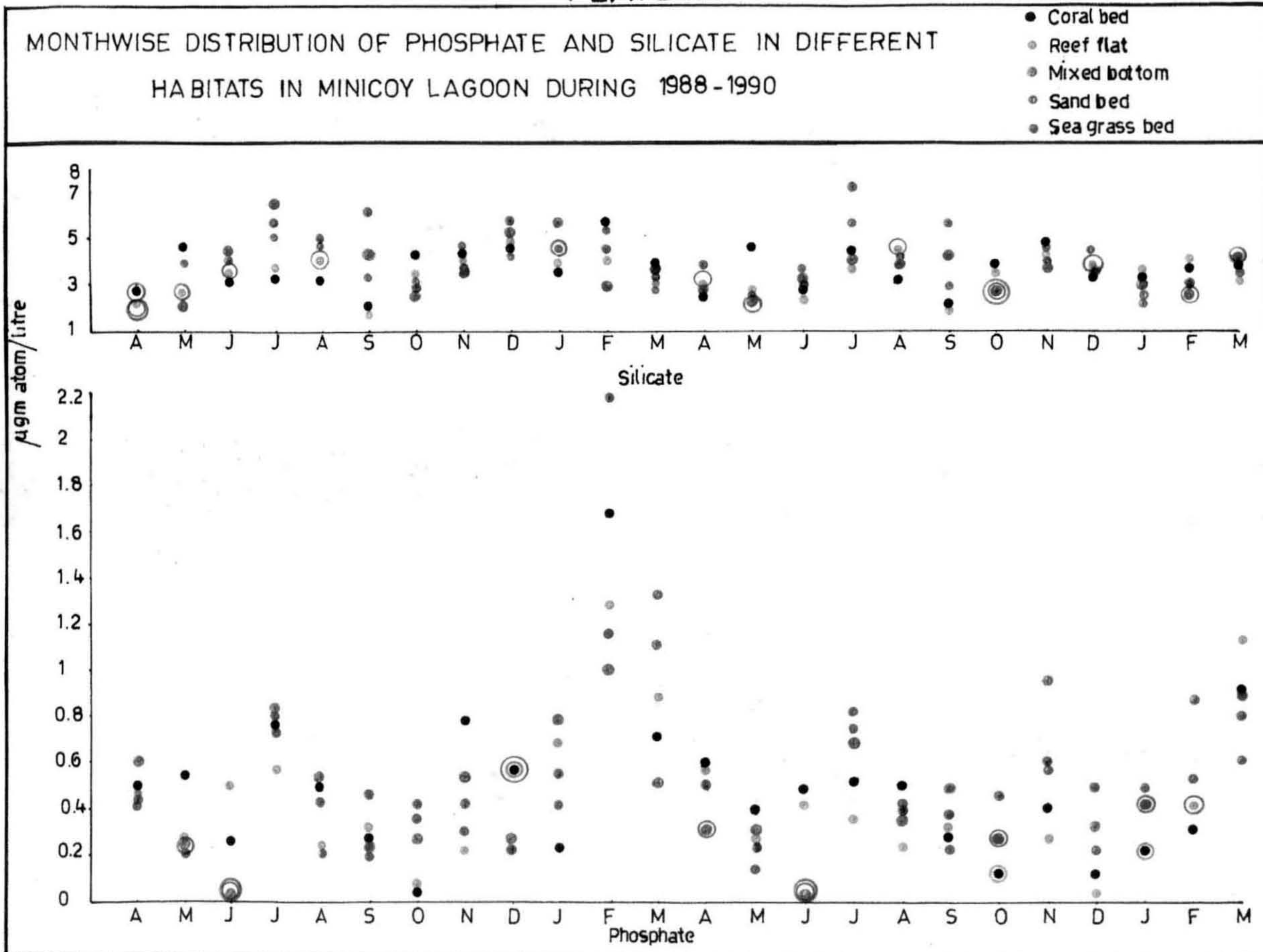

MONTHWISE DISTRIBUTION OF PHOSPHATE AND SILICATE IN DIFFERENT HABITATS IN MINICOY LAGOON DURING 1988-1990
Coral bed
Reef flat
Mixed bottom
Sand bed
Sea grass bed
µgm atom/litre
1
3
5
7
8
A M J J A S O N D J F M A M J J A S O N D J F M
Silicate
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
A M J J A S O N D J F M A M J J A S O N D J F M
Phosphate

PLATE 26

MONTHWISE DISTRIBUTION OF NITRATE AND NITRITE IN DIFFERENT HABITATS IN MINICOY LAGOON DURING 1988-1990.

- Coral bed
- Reef flat
- Mixed bottom
- Sand bed
- Seagrass bed

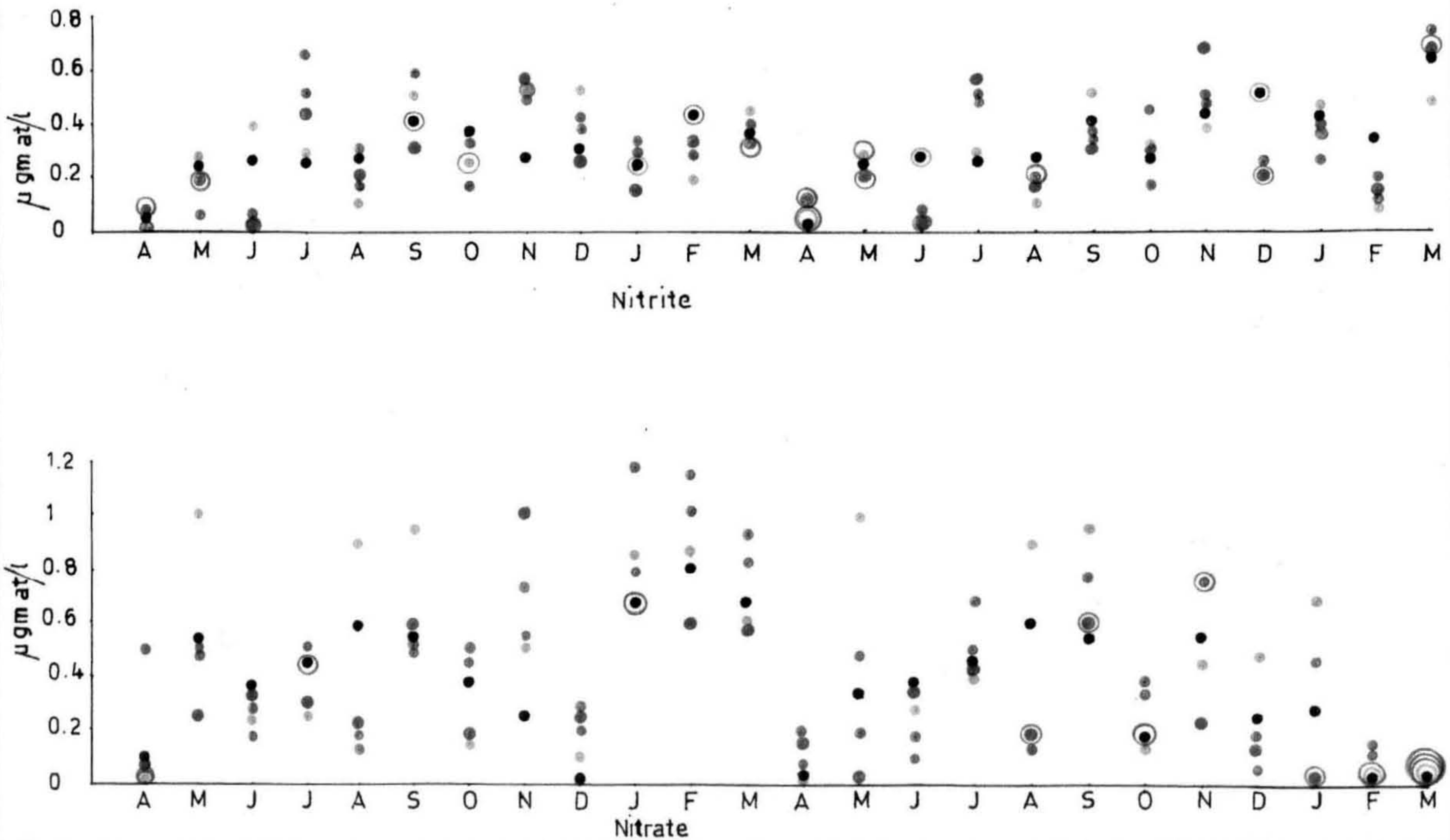


PLATE 27

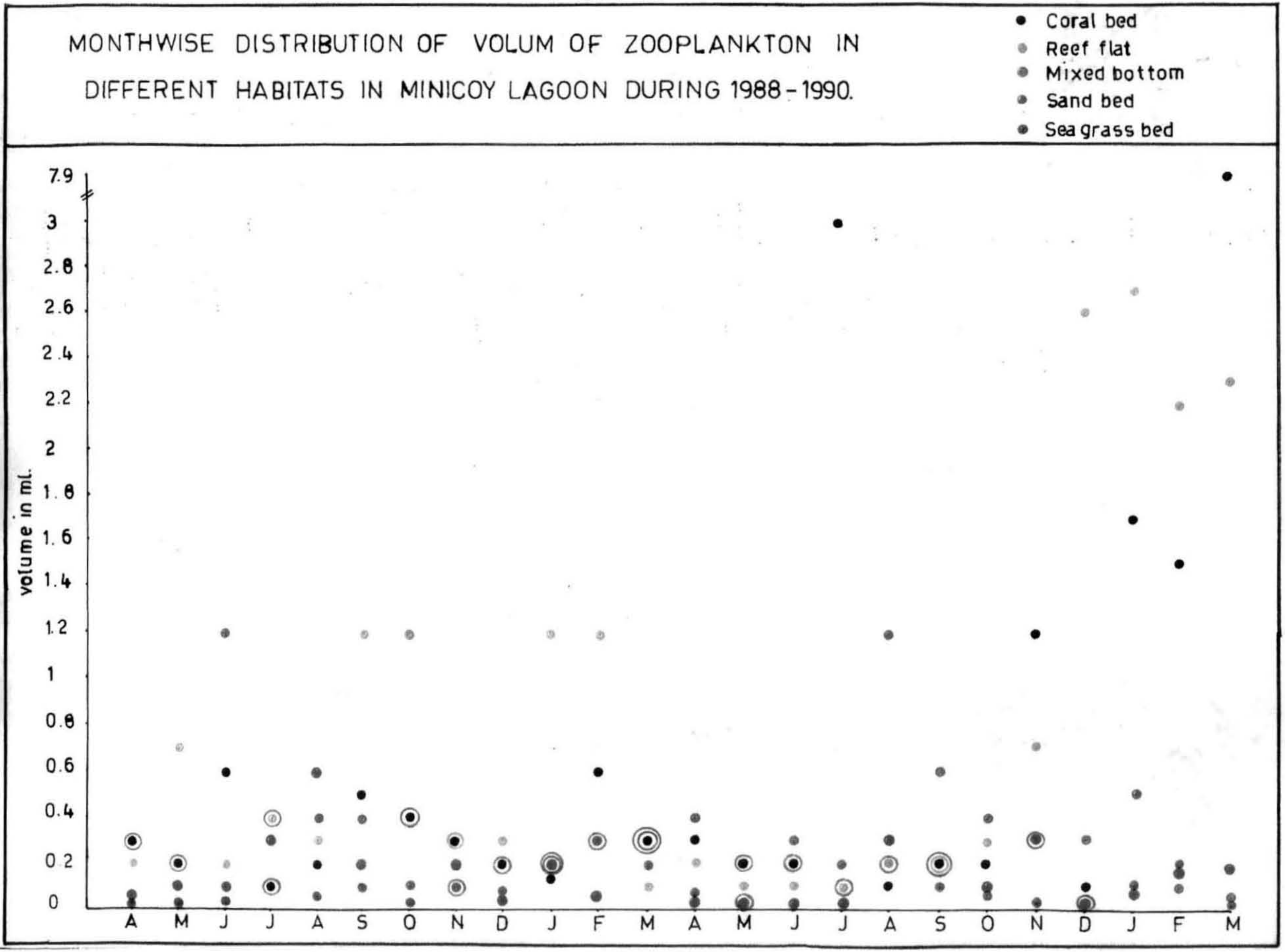

MONTHWISE DISTRIBUTION OF VOLUM OF ZOOPLANKTON IN DIFFERENT HABITATS IN MINICOY LAGOON DURING 1988-1990.
Coral bed
Reef flat
Mixed bottom
Sand bed
Sea grass bed
volume in ml.
7.9
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
A M J J A S O N D J F M A M J J A S O N D J F M

PLATE 28

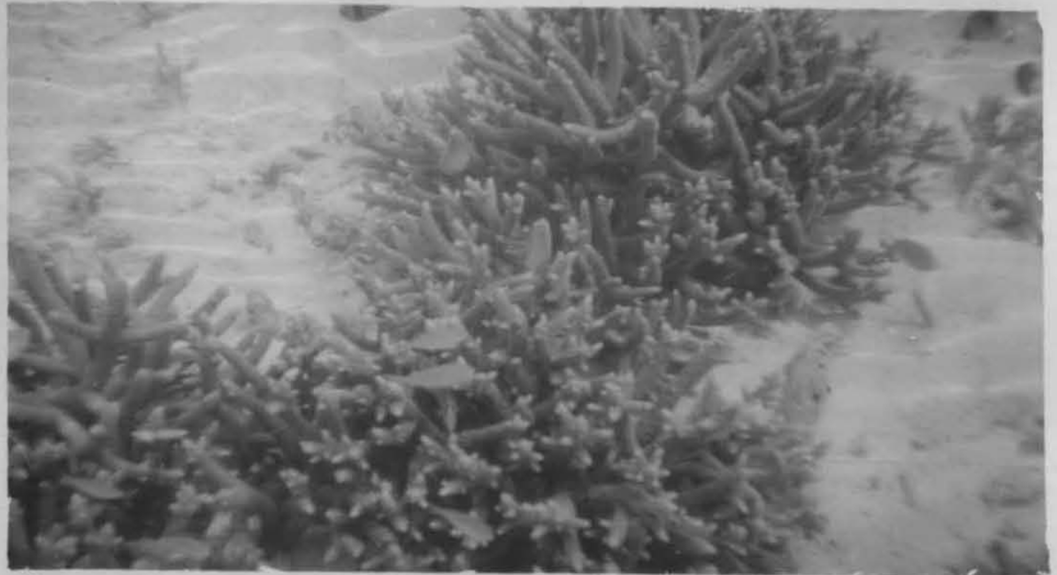
Fish sampling area between Minicoy and Viringili islands.

A view of the reef exposed during low tide

PLATE 25

A

B



C

D. Fishes showing less preference to less branched corals.

A, B & C. Co-occurrence of ornamental fishes with complex coral heads

CHAPTER - III

LENGTH - WEIGHT RELATIONSHIP

3.1. INTRODUCTION

It is well established that in any ideal fish, the length - weight relationship follows the hypothetical cube law $W = CL^3$. Most of the ornamental fishes are comparitively smaller and have peculiar form and shape at different stages of life history. Only scant information is available on the length - weight relationship of the ornamental fishes. The length - weight relationships of 15 species of *Chaetodon* has been calculated by Harmelin - Vivien and Bouchon - Navaro(1982), of *Chromis caeruleus* by Madan Mohan *et al.* (1986b) and of *Dascyllus aruanus* by Pillai *et al.* (1985).

In order to understand the length - weight relationship, 2 families namely, Chaetodontidae and Pomacentridae were selected , considering their aquarium values and availability in the lagoon. The lenght - weight relationship of 5 species under the family Chaetodontidae namely, *Chaetodon auriga, C.lunula, C.xanthocephalus, C.trifasciatus* and C.trifascialis and 2 species in the family Pomacentridae namely, *Dascyllus trimaculatus* and *D.reticulatus* has carried out.

3.2. MATERIALS AND METHODS

The general equation for the length - weight relationship is given by $W = aL^b$ or $\log W = \log a + b \log L$, where W and L are weight and length respectively and a and b are constants.

The length - weight relationship in males, females and indeterminates were calculated separately. Covariance analysis was conducted to test the significance of slope and elevation of males and females, males and indeterminats and females and indeterminates.

3.3. RESULTS AND DISCUSSION

Table 3.1 and 3.2 give the data of the stastical analysis for length - weight relationship of the fishes collected from Minicoy and Kalpeni respectively. The results showed a very high corelation coefficient indicating the linear relationship of length and weight.

The lenght - weight relationship of *C.auriga* of the Minicoy samples is given by:

Males $\log W = -3.678378 + 2.987 \log L$

$W = 0.02526392\ L^{2.987}$

Females $\log W = -3.6445901 + 2.986 \log L$

$W = 0.02613212\ L^{2.986}$

Indeterminates $\log W = -3.6145318 + 2.945 \log L$

$W = 0.02692953\ L^{2.945}$

and that of the Kalpeni samples as :

Males $\log W = -3.7185435 + 2.995 \log L$

$W = 0.0426929\ L^{2.995}$

TABLE 3.1. LENGTH-WEIGHT ANALYSIS DATA FOR THE DIFFERENT SPP. OF *CHAETODON* AND *DASCYLLUS* FROM MINICOY.

Name of species	Group	No. of Obser-vation	a value	Regre-ssion Coeff.	Corre-lation coeff.	Sum of X	Sum of Y	Corrected sum of squares of X	Corrected sum of squares of Y	Corrected sum of product of X and Y
	Males	127	-3.678	2.987	0.947	313.945875	470.628	1.884461	18.7688	5.629029
C.auriga	Females	142	-3.645	2.986	0.981	350.051603	527.692993	2.734314	25.38196	8.165161
	Indeter-minates	269	-3.615	2.945	0.985	484.079211	453.450252	21.57044	192.9614	63.15247
	Males	82	-4.11	3.262	0.693	182.678213	263.022248	0.1716614	3.808411	0.5599976
C.lunula	Females	42	-2.825	2.701	0.945	97.213433	143.871788	0.2765961	2.257843	0.7469483
	Indeter-minates	181	-3.67	3.069	0.977	354.299109	423.232233	3.456421	34.13947	10.61005
C.xanth-cephalus	Males	15	-3.06	2.719	0.916	34.969269	49.18284	0.04428101	0.3904877	0.1204071
	Indeter-minates	105	-3.362	2.861	0.985	160.069397	104.962866	3.900223	32.90282	11.15868
	Males	58	-3.419	2.941	0.985	114.971213	139.803691	4.900116	43.65366	14.4108
D.trim-aculatus	Females	199	-3.798	3.131	0.994	341.831501	314.766608	21.36597	211.9236	66.90747
	Indeter-minates	148	-3.652	3.037	0.97	142.183136	-108.671411	13.02786	127.749	39.56268
	Males	21	-3.381	2.865	0.976	34.711268	28.440767	0.4235115	3.650303	1.213268
D.reti-culatus	Females	271	-3.542	2.961	0.932	359.037236	107.960846	17.79831	159.0422	52.70746
	Indeter-minates	90	-3.537	2.863	0.94	72.336	-110.15035	1.961857	18.19251	5.615975

TABLE 3.2. LENGTH-WEIGHT ANALYSIS DATA FOR THE DIFFERENT SPP. OF *CHAETODON* AND *DASCYLLUS* FROM KALPENI.

Name of species	Group	No. of Obser-vation	a value	Regre-ssion Coeff.	Corre-lation coeff.	Sum of X	Sum of Y	Corrected sum of squares of X	Corrected sum of squares of Y	Corrected sum of product of X and Y
	Males	42	-3.72	2.985	0.99	96.85576	133.9275	0.801663	7.419586	2.401184
C.auriga	Females	159	-3.56	2.959	0.98	382.7935	566.9198	2.494202	22.82178	7.380493
	Indeter-minates	115	-3.37	2.847	0.99	194.89	166.98	16.78134	137.5891	47.78333
	Males	19	-3.88	3.131	0.92	41.40982	56.01272	0.04673004	0.5388489	0.1463242
C.lunula	Females	70	-3.37	2.932	0.98	163.4331	243.4295	0.8277588	7.422852	2.42688
	Indeter-minates	104	-4.34	3.389	0.97	188.5854	190.1712	3.233704	39.63925	10.95831
C.xanth-	Males	30	-3.76	3.078	0.89	68.13448	96.98165	0.1236267	1.483429	0.3805084
cephalus	Females	72	-4.04	3.136	0.97	176.9804	263.9998	1.003815	10.44727	3.147583
	Indeter-minates	151	-3.2	2.739	0.98	232.9271	154.906	9.337036	72.58919	25.58264
	Males	11	-4.12	3.271	1	23.88374	32.83728	0.3558693	3.809883	1.164093
C.trif-	Females	36	-3.64	3.053	0.99	79.44407	111.6522	0.4645691	4.432282	1.418533
asciatus	Indeter-minates	177	-3.41	2.953	0.99	199.0263	-14.9525	14.79132	131.6649	43.67946
C.trif-ascialis	Indeter minates	123	-3.48	2.849	0.99	140.014	-28.578	3.783579	31.170563	10.780975
	Males	47	-3.31	2.872	0.99	87.75887	96.68209	2.106293	17.80606	6.048661
D.trim-	Females	229	-3.8	3.147	0.94	362.1266	274.4366	10.82941	108.9854	33.08551
aculatus	Indeter-minates	51	-4.13	3.447	0.98	51.27857	-33.5899	1.867168	23.10172	6.436589
	Males	79	-3.76	3.086	0.98	140.0748	135.374	1.42749	14.22665	4.405762
D.reti-	Females	240	-3.75	3.097	0.99	360.6225	217.683	8.107727	79.67087	25.11261
culatus	Indeter-minates	38	-4.05	3.347	0.97	30.278	-34.211	2.7586	31.34706	9.232666

Females $\log W = -3.5593948 + 2.959 \log L$

$W = 0.02845604\ L^{2.959}$

Indeterminates $\log W = -3.3708805 + 2.847 \log L$

$W = 0.03435937\ L^{2.847}$

The covariance analysis of the males and females from both Minicoy(Table 3.3) and Kalpeni (Table 3.4) showed significant difference in the 'a' values. The covariance between males and indeterminates from samples of both Minicoy and Kalpeni showed no significant variation in slope and elevation (Table 3.5 and 3.6 respectively). Hence a single formula was derived on pooling. For the Minicoy samples, the common equation derived was:

$$\log W = -3.6084223 + 2.948 \log L$$
$$W = 0.02709456\ L^{2.948}$$

and that of the Kalpeni samples was :

$$\log W = -3.3851881 + 2.854 \log L$$
$$W = 0.03387127\ L^{2.854}$$

The covariance analysis of females and indeterminates in both the Minicoy (Table 3.7) and Kalpeni samples (Table 3.8) showed significant differences in the 'a' values.

The length - weight relationship of males, females and indeterminates of *C.lunula* from Minicoy samples was as follows :

TABLE 3.3. ANALYSIS OF COVARIANCE OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *CHAETODON AURIGA* FROM MINICOY

Groups	Corrected sum of squares SX^2	Corrected sum of product of X & SXY	Corrected st of squares c SY	Regression coefficien B	Degrees o freedom df	Sum of Squares SS	Mean Square MS
Male	1.884461	5.629029	18.7688	2.987077	125	1.954458	1.56356E-02
Female	2.734314	8.165161	25.38196	2.986183	140	0.9992962	7.13783E-03
					265	2.953755	1.114624E-02
Pooled within W	4.618775	13.79419	44.15076	2.986548	266	2.953755	1.110434E-02
			Difference between slo		1	0	0
Between B	3.173828E-03	-4.882813E-03	7.080078E-03				
W + B	4.621948	13.78931	44.15784		267	3.018265	
			Between adjusted means		1	6.451035E-0:	6.451035E-02

Slope Fcal =0   Elevation Fcal = 5.809472

Slope Ftab = 3.86   Elevation Ftab = 3.86

Slopes are NOT SIGNIFICANTLY different at 5%

Elevations are SIGNIFICANTLY different at 5%

TABLE 3.4. ANALYSIS OF COVARIANCE OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *CHAETODON AURIGA* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	0.8016663	2.401184	7.419586	2.995242	40	0.2274599	5.686498E - 03
Female	2.494202	7.380493	22.82178	2.959061	170	0.9824524	5.779132E - 03
					210	1.209912	5.761487E - 03
Pooled within	3.295868	9.781678	30.24136	2.967861	211	1.210707	5.737947E - 03
W			Difference between slopes		1	7.944107E-04	7.944107E - 04
Between							
B	0.4289551	1.557617	5.65503				
W + B	3.724823	11.3393	35.89639		212	1.376743	
			Between adjusted means		1	0.1660366	0.1660366

Slope Fcal =0.1378829 Elevation Fcal = 28.93659
Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

TABLE 3.5. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *C.AURIGA* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	1.884461	5.629029	18.7688	2.987077	125	1.954458	1.563567E - 02
Indete-	21.57044	63.52344	192.9614	2.944931	267	5.889237	2.205707E - 02
minate					392	7.843695	2.000943E - 02
Pooled							
within	23.4549	69.15247	211.7302	2.948317	393	7.846771	1.996634E - 02
W			Difference between slopes		1	3.076553E - 03	3.076553E - 03
Between	39.02039	117.2529	352.3355				
B							
W + B	62.47528	186.4054	564.0656		394	7.894104	
			Between adjusted means		1	4.733277E - 02	4.733277E - 02

Slope Fcal =0.1537552 Elevation Fcal = 2.370628

Slope Ftab = 3.86 Elevation Ftab = 3.86

Slopes are NOT SIGNIFICANTLY different at 5%

Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.6. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *C.AURIGA* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	0.8016663	2.401184	7.419586	2.995242	40	0.2274599	5.686498E - 03
Indete-	16.78134	47.78333	137.5891	2.847408	122	1.530441	0.0125446
minate					162	1.757901	1.085124E - 02
Pooled within	17.58301	50.18451	145.0086	2.854148	163	1.774612	1.088719E - 02
W			Difference between slopes		1	1.671124E-02	1.671124E - 02
Between B	10.69952	30.3421	86.04602				
W + B	28.28253	80.52661	231.0547		164	1.777618	
			Between adjusted means		1	3.005982E-03	3.005982E - 03

Slope Fcal =1.54003　　Elevation Fcal = 0.2761026

Slope Ftab = 3.89　　Elevation Ftab = 3.89

Slopes are NOT SIGNIFICANTLY different at 5%

Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.7. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF FEMALE AND INDETERMINATE *C.AURIGA* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	2.734314	8.165161	25.38196	2.986183	140	0.9992962	7.13783E-03
Indete-minate	21.56842	63.52063	192.9614	2.945076	267	5.888306	2.205358E-02
					407	6.887602	1.692285E-02
Pooled within W	24.30274	71.6858	218.3433	2.949701	408	6.891709	1.689144E-02
			Difference between slopes		1	4.106522E-03	4.106522E-03
Between B	41.15503	125.6303	383.4993				
W + B	65.45776	197.316	601.8426		409	7.052613	
			Between adjusted means		1	0.1609039	0.1609039

Slope Fcal =0.2426613 Elevation Fcal = 9.525766

Slope Ftab = 3.86 Elevation Ftab = 3.86

Slopes are NOT SIGNIFICANTLY different at 5%

Elevations are SIGNIFICANTLY different at 5%

TABLE 3.8. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF FEMALE AND INDETERMINATE *C.AURIGA* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	2.494202	7.380493	22.82178	2.959061	170	0.9824524	5.779132E-03
Indete-	16.78134	47.78333	137.5891	2.847408	122	1.530441	0.012[illegible]446
minate					292	2.512894	8.605801E-03
Pooled							
within	19.27554	55.16382	160.4108	2.861856	293	2.539948	8.668762E-03
W			Difference between slopes		1	2.705383E - 02	2.705383E-02
Between							
B	34.97583	103.6849	307.3699				
W + B	54.25138	158.8488	467.7807		294	2.669434	
			Between adjusted means		1	0.1294861	0.129[illegible]861

Slope Fcal =3.143674 Elevation Fcal = 14.93709
Slope Ftab = 3.86 Elevation Ftab = 3.86

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

Males $\log W = -4.1100557 + 3.262 \log L$

$W = 0.01640686\ L^{3.262}$

Females $\log W = -2.8250772 + 2.701 \log L$

$W = 0.05930408\ L^{2.701}$

Indeterminates $\log W = -3.67004244 + 3.069 \log L$

$W = 0.02546566\ L^{3.069}$

The formulae for the length - weight relations of *C.lunula* from the Kalpeni samples are given by:

Males $\log W = -3.876443 + 3.131 \log L$

$W = 0.02072441\ L^{3.131}$

Females $\log W = -3.3676401 + 2.932 \log L$

$W = 0.03447089\ L^{2.932}$

Indeterminates $\log W = -4.34212138 + 3.389 \log L$

$W = 0.01328375\ L^{3.389}$

The slope and elevations in the males and females of the Minicoy samples did not vary significantly (Table 3.9)and hence a common formula has been derived to express the length - weight relationship of *C.lunula*. It is given by:

$$\log W = -3.3265214 + 2.916 \log L$$
$$W = 0.03591783\ L^{2.916}$$

whereas in the Kalpeni samples the 'a' value varied significantly (Table 3.10). The covariance analysis showed no significant difference in slope and elevation between the males and indeterminates in the Minicoy samples of *C.lunula* (Table 3.11) and the common equation derived is:

TABLE 3.9. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *C.LUNULA* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	0.1716614	0.5599976	3.808411	3.262222	79	1.981574	2.508322E - 02
Female	0.2765961	0.7469483	2.257843	2.700502	40	0.2407079	6.017697E - 03
					119	2.222282	1.867464E - 02
Pooled within W	0.4482575	1.306946	6.066254	2.915614	120	2.255704	1.879753E - 02
			Difference between slopes		1	3.342176E - 02	3.342176E - 02
Between B	9.722901E - 02	0.2924805	0.8795166				
W + B	0.5454865	1.599426	6.945771		121	2.256077	
			Between adjusted means		1	3.731251E - 04	3.731251E - 04

Slope Fcal =1.789687 Elevation Fcal = 1.984969E - 02
Slope Ftab = 3.92 Elevation Ftab = 3.92

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.10. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *C.LUNULA* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	4.673004E - 02	0.1463242	0.5388489	3.131266	17	8.066911E-02	4.745242E - 03
Female	0.8277588	2.42688	7.422852	2.931869	68	0.3075595	4.522934E - 03
					85	0.3882286	4.567396E - 03
Pooled within W	0.8744888	2.573204	7.961701	2.942524	86	0.389987	4.534733E - 03
			Difference between slopes		1	1.758397E - 03	1.758397E - 03
Between B	0.3604126	1.228882	4.190247		87	0.4458647	
W + B	1.234901	3.802086	12.15195		1	5.587769E - 02	5.587769E - 02
			Between adjusted means				

Slope Fcal =0.3849889 Elevation Fcal = 12.32216
Slope Ftab = 3.96 Elevation Ftab = 3.96

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

TABLE 3.11. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *C.LUNULA* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	0.1716614	0.5599976	3.808411	3.262222	79	1.981574	2.508322E - 02
Indete-	3.456421	10.61005	34.13947	3.069663	179	1.570202	8.772078E - 03
rminate					258	3.551776	1.376657E - 02
Pooled							
within	3.628082	11.17004	37.94788	3.078774	259	3.557839	1.373683E - 02
W			Difference between slopes		1	6.062508E - 03	6.062508E - 03
Between							
B	4.963623	15.14758	46.22583				
W + B	8.591706	26.31763	84.17371		260	3.559036	
			Between adjusted means		1	1.197815E - 03	1.197815E - 03

Slope Fcal =0.4403788 Elevation Fcal = 8.719734E - 02
Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

$$\log W = -3.6907476 + 3.078 \log L$$
$$W = 0.02495334\ L^{3.078}$$

whereas in the Kalpeni samples the elevations were significantly different (Table 3.12). In the covariance analysis between females and indeterminates, the 'a' values were not significantly different, but the slopes were significantly different in both the samples of Minicoy and Kalpeni (Table 3.13 and 3.14 respectively).

In the case of *C.xanthocephalus* of Minicoy samples, the length - weight relationship was as follows:

Males $\log W = -3.0602778 + 2.719 \log L$
$W = 0.04687467\ L^{2.719}$

Indeterminates $\log W = -3.3619183 + 2.861 \log L$
$W = 0.03466869\ L^{2.861}$

The relationship of females was not analysed. In the Kalpeni samples, the relationship was :

Males $\log W = -3.7568217 + 3.078 \log L$
$W = 0.02335786\ L^{3.078}$

Females $\log W = -4.0408859 + 3.136 \log L$
$W = 0.1758189\ L^{3.136}$

Indeterminates $\log W = -3.2006183 + 2.739 \log L$
$W = 0.04073701\ L^{2.739}$

The covariance analysis between males and females of the Kalpeni samples showed significant variation in the 'a' value (Table 3.15). The covariance in males and

TABLE 3.12. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *C.LUNULA* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	4.673004E - 02	0.1463242	0.5388489	3.131266	17	8.066911E-02	4.745242E - 03
Indete-rminate	3.233704	10.95831	39.63925	3.388781	102	2.503929	2.454833E - 02
					119	2.584598	2.171932E - 02
Pooled within W	3.280434	11.10464	40.1781	3.385113	120	2.587654	2.156379E - 02
			Difference between slopes		1	3.055811E-03	3.055811E - 03
Between B	2.136932	6.559204	20.1329				
W + B	5.417366	17.66384	60.31101		121	2.716354	
			Between adjusted means		1	0.1287003	0.1287003

Slope Fcal =0.1406956 Elevation Fcal = 5.968352
Slope Ftab = 3.92 Elevation Ftab = 3.92

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

TABLE 3.13. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF FEMALE AND INDETERMINATE *C. LUNULA* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	0.2765961	0.7469483	2.257843	2.700502	40	0.2407079	6.017697E - 03
Indete-	3.456543	10.6106	34.13947	3.069713	179	1.567978	8.759653E - 03
rminate					219	1.808686	8.25884E - 03
Pooled							
within	3.733139	11.35754	36.39731	3.042358	220	1.843597	8.379988E - 03
W			Difference between slopes		1	3.491163E-02	3.491163E - 02
Between							
B	4.350403	13.24011	40.29553				
W + B	8.083542	24.59766	76.69284		221	1.843887	
			Between adjusted means		1	2.89917E-04	2.89917E - 04

Slope Fcal =4.227184 Elevation Fcal = 3.459635E - 02

Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are SIGNIFICANTLY different at 5%

Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.14. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF FEMALE AND INDETERMINATE *C.LUNULA* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	0.8277588	2.42688	7.422852	2.931869	68	0.3075595	4.522934E - 03
Indete-	3.233704	10.95831	39.63925	3.388781	102	2.503929	2.454833E - 02
rminate					170	2.811489	1.653817E - 02
Pooled							
within	4.061463	13.38519	47.06211	3.295658	171	2.949078	
W			Difference between slopes		1	0.137589	1.724607E - 02
Between							0.137589
B	11.31378	35.87695	113.7683		172	2.994934	
W + B	15.37524	49.26215	160.8304		1	4.585648E-02	4.585648E - 02
			Between adjusted means				

Slope Fcal =8.319481	Elevation Fcal = 2.658953
Slope Ftab = 3.89	Elevation Ftab = 3.89

Slopes are SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

indeterminates of the Minicoy sample was not significantly different in slopes and elevations (Table 3.16) and hence a common formula is derived, which is given as :

$$\log W = -3.3629688 + 2.859 \log L$$
$$W = 0.03463229\ L^{2.859}$$

But in the Kalpeni samples, the 'a' values showed no significant difference but the slopes varied significantly between males and indeterminates (Table 3.17). Both slopes and elevations were significantly different in the case of females and indeterminates (Table 3.18).

The length - weight relationship of *C. trifasciatus* was as follows :

Males	$\log W = -4.1171026 + 3.271 \log L$
	$W = 0.01629165\ L^{3.271}$
Females	$\log W = -3.6368162 + 3.053 \log L$
	$W = 0.02633606\ L^{3.053}$
Indeterminates	$\log W = -3.4050081 + 2.953 \log L$
	$W = 0.03320655\ L^{2.953}$

Covariance analysis between males and females (Table 3.19) showed no significant variation in slopes and elevation. Hence the pooled equation is :

$$\log W = -3.846188 + 3.147 \log L$$
$$W = 0.02136101\ L^{3.147}$$

TABLE 3.15. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *C.XANTHOCEPHALUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	0.1236267	0.3805084	1.483429	3.077882	28	0.312269	1.115246E - 02
Female	1.003815	3.147583	10.44727	3.135622	70	0.5776368	8.251953E - 03
					98	0.8899057	9.080671E - 03
Pooled within W	1.127441	3.528092	11.9307	3.12929	99	0.8902731	8.992657E - 03
			Difference between slopes		1	3.67403E-04	3.67403E - 04
Between B	0.7398682	1.7146	3.973145				
W + B	1.86731	5.242691	15.903384		100	1.184368	
			Between adjusted means		1	0.2940951	0.2940951

Slope Fcal =0.0404599 Elevation Fcal = 32.70391
Slope Ftab = 3.94 Elevation Ftab = 3.94

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

TABLE 3.16. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *C.XANTHOCEPHALUS* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	4.428101E - 03	0.1204071	0.3904877	2.719159	13	0.0630816	4.85243E - 03
Indet-erminate	3.900223	11.15868	32.90282	2.861036	103	0.9774475	9.489781E - 03
					116	1.040529	8.970079E - 03
Pooled within	3.944504	11.27908	33.29331	2.859443	117	1.041409	8.900928E - 03
W			Difference between slopes		1	8.794069E-04	8.794069E - 04
Between B	8.543732	24.13551	68.18169				
W + B	12.48824	35.4146	101.475		118	1.044983	
			Between adjusted means		1	3.574371E-03	3.574371E - 03

Slope Fcal = 9.803782E - 02 Elevation Fcal = 0.4015729
Slope Ftab = 3.92 Elevation Ftab = 3.92

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.17. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *C.XANTHOCEPHALUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	0.1236267	0.3805084	1.483429	3.077882	28	0.312269	1.115246E - 02
Indet-	9.337036	25.58264	72.58919	2.73991	149	2.495041	1.674524E - 02
erminate					177	2.80731	1.586051E - 02
Pooled							
within	9.460663	25.96315	74.07262	2.744327	178	2.821251	1.584973E - 02
W			Difference between slopes		1	1.394105E-02	1.394105E - 02
Between							
B	13.28555	40.25586	121.9766				
W + B	22.74622	66.21901	196.0492		179*	3.271744	
			Between adjusted means		1	0.4504929	0.4504929

Slope Fcal = 0.8789788 Elevation Fcal = 28.42276
Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

TABLE 3.18. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF FEMALE AND INDETERMINATE *C.XANTHOCEPHALUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	1.003815	3.147644	10.44727	3.135682	70	0.5772533	8.246477E - 03
Indet-erminate	9.337036	25.58333	72.5936	2.739984	149	2.49569	1.674959E - 02
Pooled					219	3.072943	0.0140317
within	10.34085	28.73097	83.04086	2.778396	220	3.214867	1.461303E - 02
W			Difference between slopes		1	0.1419239	0.1419239
Between							
B	40.86194	117.8691	340.0017				
W + B	51.20279	146.6001	423.0425		221	3.308075	
			Between adjusted means		1	9.320831E-02	9.320831E-02

Slope Fcal = 10.11452 Elevation Fcal = 6.378439
Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

TABLE 3.19. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *C. TRIFASCIATUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	0.3558693	1.164093	3.809883	3.271125	9	1.989126E-03	2.21014E - 04
Female	0.4645691	1.418533	4.432282	3.053439	34	0.1008768	2.966965E - 03
					43	0.1028659	2.392231E - 03
Pooled							
within	0.8204384	2.582626	8.242165	3.147862	44	0.1124153	2.554894E - 03
W			Difference between slopes		1	9.549379E-03	9.549379E - 03
Between							
B	1.065064E-02	3.475952E - 02	0.113678				
W + B	0.831089	2.617386	8.355843		45	0.112792	
			Between adjusted means		1	3.767014E-04	3.767014E-04

Slope Fcal = 3.99183 Elevation Fcal = 0.1474431

Slope Ftab = 4.06 Elevation Ftab = 4.06

Slopes are NOT SIGNIFICANTLY different at 5%

Elevations are NOT SIGNIFICANTLY different at 5%

There was no significant difference in the 'a' values of males and indeterminates also (Table 3.20). The pooled equation is :

$$\log W = -3.4151252 + 2.961 \log L$$
$$W = 0.03287229\ L^{2.961}$$

The females and indeterminates when tested for covariance showed significant differences in slope and elevation(Table 3.21)

The lenght - weight relationship of the indeterminates *C.trifascialis* is given by:

$$\log W = -3.4758981 + 2.849 \log L$$
$$W = 0.03093404\ L^{2.849}$$

The length - weight relationship of *D.trimaculatus* in the Minicoy samples was as follows:

Males	$\log W = -3.4185345 + 2.941 \log L$
	$W = 0.03276041\ L^{2.941}$
Females	$\log W = -3.7977983 + 3.131 \log L$
	$W = 0.0242008\ L^{3.131}$
Indeterminates	$\log W = -3.6516866 + 3.037 \log L$
	$W = 0.02594733\ L^{3.037}$

In the Kalpeni samples the relationship was found to be :

Males	$\log W = -3.3050186 + 2.872 \log L$
	$W = 0.03669853\ L^{2.872}$

TABLE 3.20. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *C. TRIFASCIATUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	0.3558693	1.164093	3.809883	3.271125	9	1.989126E-03	2.21014E - 04
Indeter minate	14.79132	43.67946	131.6649	2.953047	175	2.677384	1.529933E - 02
					184	2.679373	1.456181E - 02
Pooled within	15.14719	44.84355	135.4747	2.96052	185	2.714523	0.0146731
W			Difference between slopes		1	3.515077E-02	3.515077E - 02
Between B	11.34854	33.28013	97.59533				
W + B	26.49573	78.12369	253.0701		186	2.71936	
			Between adjusted means		1	4.837036E-03	4.837036E - 03

Slope Fcal = 2.413901 Elevation Fcal = 0.3296534
Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.21. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF FEMALE AND INDETERMINATE *C.TRIFASCIATUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	0.4645691	1.418533	4.432282	3.053439	34	0.1008768	2.966965E - 03
Indeter minate	14.79132	43.67946	131.6649	2.953047	175	2.686121	1.5349793E - 02
Pooled					209	2.6774111	1.2810579E - 02
within	15.25589	45.09799	136.0868	3.003243	210	2.7724735	1.3202254E - 02
W			Difference between slopes		1	9.50624E-02	9.50624E - 02
Between							
B	35.04462	103.15371	303.6417				
W + B	50.30051	148.2517	439.7286		211	3.397003	
			Between adjusted means		1	0.6245295	0.6245295

Slope Fcal = 7.4206169 Elevation Fcal = 47.1508135

Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are SIGNIFICANTLY different at 5%

Elevations are SIGNIFICANTLY different at 5%

Females $\log W = -3.7978286 + 3.147 \log L$

$W = 0.02241914\ L^{3.147}$

Indeterminates $\log W = -4.1247015 + 3.447 \log L$

$W = 0.01616832\ L^{3.447}$

The analysis of covariance between males and females of Minicoy and Kalpeni samples showed significant difference in slopes (Table 3.22 and Table 3.23). No significant difference was observed between slopes and elevataions of males and indeterminates of Minicoy samples (Table 3.24), whereas the slopes varied significantly in the Kalpeni samples (Table 3.25).The 'a' and 'b' values showed no significant variation between females and indeterminates of Minicoy samples (Table 3.26), but the 'a' values varied significantly for the Kalpeni samples (Tabel 3.27). The common formula derived for males and indeterminates in the Minicoy samples is as follows:

$$\log W = -3.6068369 + 3.011 \log L$$
$$W = 0.02713755\ L^{3.011}$$

and that for females and indeterminates was :

$$\log W = -3.7242484 + 3.096 \log L$$
$$W = 0.02413123\ L^{3.096}$$

The length weight relationship of *D.reticulatus* in the Minicoy samples is calculated as :

Males $\log W = -3.3809269 + 2.865 \log L$

$W = 0.03401591\ L^{2.865}$

TABLE 3.22. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *D. TRIMACULATUS* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	4.900116	14.4108	43.65366	2.94091	56	1.272808	2.272872E - 02
Female	21.36597	66.90747	211.9236	3.131498	197	2.403015	1.219805E - 02
					253	3.675823	1.452895E - 02
Pooled within W	26.26608	81.31827	255.5773	3.095942	254	3.820603	1.50417E - 02
			Difference between slopes		1	0.1447792	0.1447792
Between B	3.142334	9.857666	30.92407				
W + B	29.40842	91.17593	286.5013		255	3.825409	
			Between adjusted means		1	4.806519E-03	4.806519E-03

Slope Fcal = 9.964881 Elevation Fcal = 0.3195454

Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are SIGNIFICANTLY different at 5%

Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.23. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *D.TRIMACULATUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	2.106293	6.048661	17.80606	2.871709	45	0.4360676	9.690391E - 03
Female	10.82941	34.08551	108.9854	3.147496	227	1.701355	7.494956E - 03
					272	2.137423	7.858171E - 03
Pooled within W	12.9357	40.13417	126.7914	3.10259	273	2.271546	8.320679E - 03
			Difference between slopes		1	0.1341229	0.1341229
Between B	3.080872	9.454407	29.01309				
W + B	16.01657	49.58858	155.8045		274	2.274338	
			Between adjusted means		1	2.792359E-03	2.792359E-03

Slope Fcal = 17.06795 Elevation Fcal = 0.3355926
Slope Ftab = 3.86 Elevation Ftab = 3.86

Slopes are SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.24. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *D. TRIMACULATUS* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	4.900116	14.4108	43.65366	2.94091	56	1.272808	2.272872E - 02
Indeterminate	13.02786	39.56268	127.749	3.036774	146	7.606079	5.209644E - 02
					202	8.878887	4.395489E - 02
Pooled within W	17.92798	53.97348	171.4027	3.010572	203	8.911621	4.389961E - 02
			Difference between slopes		1	3.273392E-02	3.273392E - 02
Between B	43.48654	133.8945	412.2594				
W + B	61.41452	187.868	583.662		204	8.971069	
			Between adjusted means		1	5.944824E-02	5.944824E-02

Slope Fcal = 0.7447163 Elevation Fcal = 1.354186

Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are NOT SIGNIFICANTLY different at 5%

Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.25. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *D.TRIMACULATUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Male	2.106293	6.048661	17.80611	2.871709	45	0.4361134	9.691408E - 03
Indeterminate	1.867168	6.436589	23.10172	3.447246	49	0.9132176	1.863709E - 02
Pooled					94	1.349331	1.435458E - 02
within	3.973461	12.48525	40.90783	3.14216	95	1.677181	1.765454E - 02
W			Difference between slopes		1	0.3278504	0.3278504
Between							
B	18.16359	57.24039	180.386				
W + B	22.13705	69.72563	221.2939		96	1.677246	
			Between adjusted means		1	6.484986E-05	6.484986E - 05

Slope Fcal = 22.83942 Elevation Fcal = 3.678268E- 03
Slope Ftab = 3.94 Elevation Ftab = 3.94

Slopes are SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.26. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF FEMALE AND INDETERMINATE *D.TRIMACULATUS* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	21.36597	66.90747	211.9236	3.131498	197	2.403015	1.219805E - 02
Indeterminate	13.02786	39.56268	127.749	3.036774	146	7.606079	5.209644E - 02
Pooled					343	10.00909	2.918103E - 02
within	34.39383	106.4702	339.6726	3.095618	344	10.08173	2.930734E - 02
W			Difference between slopes		1	7.263184E-02	7.263184E - 02
Between							
B	48.64441	148.7886	455.0996				
W + B	83.03824	255.2588	794.7722		345	10.10919	
			Between adjusted means		1	2.746582E-02	2.746582E - 02

Slope Fcal = 2.489009 Elevation Fcal = 0.9371651
Slope Ftab = 3.86 Elevation Ftab = 3.86

Slopes are NOTSIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.27. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP
OF FEMALE AND INDETERMINATE *D.TRIMACULATUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	10.82941	34.08551	108.9854	3.147496	227	1.701355	7.494956E - 03
Indeterminate	1.867168	6.436589	23.10172	3.447246	49	0.9132176	1.863709E - 02
Pooled					276	2.614573	9.473089E - 03
within	12.69658	40.5221	142.0871	3.191577	277	2.75766	9.955451E - 03
W			Difference between slopes		1	0.1430874	0.1430874
Between							
B	14.06415	44.88364	143.2401				
W + B	26.76072	85.40573	275.3272		278	2.758362	
			Between adjusted means		1	7.019043E-04	7.019043E-04

Slope Fcal = 15.10462 Elevation Fcal = 7.050453E - 02
Slope Ftab = 3.86 Elevation Ftab = 3.86

Slopes are SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

Females $\log W = -3.5422213 + 2.961 \log L$

$W = 0.02894895\ L^{2.961}$

Indeterminates $\log W = -3.5373677 + 2.863 \log L$

$W = 0.0290898\ L^{2.863}$

In the Kalpeni samples the relationship observed was :

Males $\log W = -3.7588407 + 3.086 \log L$

$W = 0.02331075\ L^{3.086}$

Females $\log W = -3.7465403 + 3.097 \log L$

$W = 0.02359925\ L^{3.097}$

Indeterminates $\log W = -4.0518283 + 3.347 \log L$

$W = 0.01739055\ L^{3.347}$

The Minicoy samples, the slopes and elevations were not significantly different between males and females (Table 3.28), but the elevations differed significantly in the Kalpeni samples (Table 3.29). Both 'a' and 'b' values were not significantly varied in Minicoy samples for males and indeterminates (Table 3.30), but the 'b' values were significantly different in the Kalpeni samples (Table 3.31). The 'b' values showed variation at 5% level between females and indeterminates of Minicoy samples (Table 3.32), whereas both 'a' and 'b' values varied at 5% level for the Kalpeni samples (Table 3.33). The common equation derived to represent the length - weight relationship of males and females of Minicoy samples is :

$$\log W = -3.5346395 + 2.955 \log L$$

TABLE 3.28. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *D.RETICULATUS* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Males	0.4235115	1.213268	3.650303	2.864782	19	0.1745534	9.187021E - 03
Females	17.79831	52.70746	159.0422	2.961375	269	2.9556762	1.0987643E - 02
					288	3.1302296	1.0868852E - 02
Pooled within W	18.22182	53.920728	162.692503	2.93130785	289	3.1340776	1.0844559E - 02
			Difference between slopes		1	3.848E - 03	3.848E - 03
Between B	2.09751	6.112042	17.81022				
W + B	20.31933	60.03277	180.50272		290	3.1379411	
			Between adjusted means		1	3.8635E - 03	3.8635E - 03

Slope Fcal = 0.35403923 Elevation Fcal = 0.356261605
Slope Ftab = 3.89 Elevation Ftab = 3.89

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.29. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND FEMALE *D.RETICULATUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Males	1.42749	4.405762	14.22665	3.086	77	0.628839	8.166E - 03
Females	8.107727	25.11261	79.67087	3.097	238	1.887888	7.932E - 03
					315	2.516727	7.989E - 03
Pooled within W	9.535217	29.518372	93.89752	3.092	316	2.516874	7.964E - 03
			Difference between slopes		1	1.47E - 04	1.47E - 04
Between B	4.349105	12.953337	38.707283				
W + B	13.884322	42.471709	132.604803		317	2.6851667	
			Between adjusted means		1	0.1682927	0.1682927

Slope Fcal = 0.0184003 Elevation Fcal = 21.131680
Slope Ftab = 3.86 Elevation Ftab = 3.86

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

TABLE 3.30. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *D.RETICULATUS* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Males	0.4235115	1.213268	3.650303	2.864782	19	0.1745534	9.187021E - 03
Indeterminate	1.961857	5.615975	18.19251	2.862581	88	2.116322	2.404911E - 02
Pooled					107	2.290875	2.141005E - 02
within W	2.385368	6.829243	21.84281	2.862972	108	2.290877	2.121182E -02
			Difference between slopes		1	1.430512E-06	1.430512E - 06
Between B	12.15024	37.08351	113.1819				
W + B	14.53561	43.91275	135.0248		109	2.362274	
			Between adjusted means		1	7.139778E-02	7.139778E - 02

Slope Fcal = 6.681497E - 05 Elevation Fcal = 3.365944
Slope Ftab = 3.94 Elevation Ftab = 3.94

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.31. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF MALE AND INDETERMINATE *D. RETICULATUS* FROM KALPENI

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Males	1.42749	4.405762	14.22665	3.086369	77	0.6288471	8.166846E - 03
Indeterminate	2.7586	9.232666	31.34706	3.346866	36	0.4465637	1.240455E - 02
Pooled					113	1.075411	9.51691E - 03
within W	4.186091	13.63843	45.57372	3.258035	114	1.139244	9.993369E - 03
			Difference between slopes		1	6.383324E-02	6.383324E - 02
Between B	24.45639	77.62119	246.3593				
W + B	28.64248	91.25961	291.933		115	1.165039	
			Between adjusted means		1	2.579498E-02	2.579498E - 02

Slope Fcal = 6.70735   Elevation Fcal = 2.58121
Slope Ftab = 3.94   Elevation Ftab = 3.94

Slopes are SIGNIFICANTLY different at 5%
Elevations are NOT SIGNIFICANTLY different at 5%

TABLE 3.32. COVARIANCE ANALYSIS OF LENGTH - WEIGHT RELATIONSHIP OF FEMALE AND INDETERMINATE *D.RETICULATUS* FROM MINICOY

Groups	Corrected sum of squares of X SX^2	Corrected sum of product of X & Y SXY	Corrected sum of squares of Y SY^2	Regression coefficient B	Degrees of freedom df	Sum of Squares SS	Mean Square MS
Female	17.79831	52.70746	159.0422	2.961375	269	2.955628	1.098746E - 02
Indeterminate	1.961857	5.615975	18.19251	2.862581	88	2.116322	2.404911E - 02
Pooled					357	5.071949	1.420714E - 02
within W	19.76017	58.32344	177.2347	2.951566	358	5.089188	1.421561E - 02
			Difference between slopes		1	1.723862E-02	1.723862E - 02
Between B	18.03796	56.03498	174.0729				
W + B	37.79813	114.3584	351.3076		359	5.315705	
			Between adjusted means		1	0.2265167	0.2265167

Slope Fcal = 1.213377 Elevation Fcal = 15.93437
Slope Ftab = 3.86 Elevation Ftab = 3.86

Slopes are NOT SIGNIFICANTLY different at 5%
Elevations are SIGNIFICANTLY different at 5%

$$W = 0.02916927\ L^{2.955}$$

and that for males and indeterminates is :

$$\log W = -3.50746 + 2.863 \log L$$
$$W = 0.02997295\ L^{2.863}$$

All of the fishes and their different categories such as males, females and indeterminates were found to be following the linear relationship of length and weight. Since the males and females showed significant differences in slope and elevation, the males and females follow separate linear relationship between males and females. In the case of chaetodons, the weight of the mature testis and mature ovary vary significantly, as in the mature and immature males the weight of testis does not vary much, but in the case of females the weight of immature and mature ovaries vary greatly as given in the chapter V of this thesis. This may be the reason why the males and females showed significant variation in slopes and elevation.

The difference in the length - weight relationship in males, females and indeterminates of pomacentrids may be considered on account of the variation in the degree of fullness of stomachs and also on account of sex reversal in these fishes as pointed out in chapter V of this thesis.

In length - weight relationship, the range of regression coefficient in the various chaetodons given by Harmelin-Vivien and Bouchon-Navaro (1989) was observed between 2.033 (for *C.auriga*) and 4.787 (for *C.citrinellus*).

Madan mohan *et al.* (1986b) and Pillai *et al.* (1985a) showed that *Chromis caeruleus* and *D.aruanus* also follow the linear relationship between length and weight.

¶¶¶¶¶¶¶¶¶

CHAPTER IV

FOOD AND FEEDING HABITS

Pl. 30-38

4.1 INTRODUCTION

Most of the reef fishes are aquarium pets and the knowledge of their food and feeding habits will be of much importance in view of maintaining them in the aquarium with proper feed. Information on natural food and feeding habits will be also useful to the aquarists in preparing the right artifical feed for the various ornamental fishes. Hence a study on the food and feeding habits of selected ornamental fishes is attempted in the present study.

For the present study fishes belonging to two families, Chaetodontidae and Pomacentridae were selected, as these fishes have attracted a great deal of attention from both the scientific community and the aquarium fish industry. The chaetodons studied were *Chaetodon auriga, C.lunula, C.xanthocephalus, C.trifasciatus* and *C.trifascialis* and the pomacentrids were *Dascyllus trimaculatus* and *D.reticulatus*.

Considerable information is available on the feeding habits of butterfly fishes in the Indo - pacific (Hiatt and Strasburg 1960, Talbot 1965, Hobson 1968, 1974, Reese 1975, 1977, Neudecker 1977, 1979, Ralston 1981, Harmelin - Vivien and Bouchon - Navaro 1982, 1983, Sano *et al.* 1984b, Sano 1989, Kung and Ciereszko 1985, Tricas 1985, Cox 1986) and the Caribbean (Randall 1967, Birkland and Neudecker 1981, Gore 1984, Lasker 1985, Neudecker 1985).

Motta (1982, 1985 and 1988) investigated the functional morphology and dentition pattern of butterfly fishes in relation to their feeding behaviour. Cox (1994) investigated the resource use by corallivorous butterfly fishes in Hawaii.

Detailed studies on the food and feeding habits of the pomacentrids, especially that of the *Dascyllus spp.* are lacking. But some studies on the feeding biology of the damselfishes have been made by Hiatt and Strasburg (1960), John and Pople (1973), Coats (1980), Duke and Shevchenko (1980), Williams (1980), Montogomeri (1980a, b), Tribble and Nishikawa (1982), Lassuy (1984), Madan Mohan *et al.* (1986b) and Pillai *et al.* (1985a). The patterns of searching behaviour for local preys by *Chromis chrysurus* was given by Noda *et al.* (1994). The diet of *D.trimaculatus* and *D.reticulatus* has been reported by Vijay Anand (1994).

4.2.MATERIALS AND METHODS

The number of fishes analysed monthwise ranged between 15 and 56 for *C.auriga* and between 15 and 30 for the other Chaetodons namely, *C.lunula*, *C.xanthocephalus*, *C.trifasciatus* and *C.trifascialis*. Number of *D.trimaculatus* ranged between 20 and 49 and that of *D.reticulatus* between 20 and 57.

The stomachs of the fishes were preserved in 5% formalin. To find out the feeding intensity, the degree of fullness of the stomach was designated as gorged, full, 3/4 full, 1/2 full ,1/4 full and empty, depending on the relative fullness of the stomach. Fishes with gorged and full stomachs were considered as actively fed fishes; those with 3/4 and 1/2 full stomachs as moderately fed and the fishes with 1/4 full and empty stomachs as poorly fed ones.

The food components were identified upto order/family/genus/species level depending upon the condition of each item in the stomachs. The food items were ranked based on the index of preponderence, which was calculated using the formula,

$$I_i = \frac{V_i O_i}{\sum V_i O_i} \times 100$$

where V_i and O_i are the percentage volume and percentage occurence of each food item respectively (Natarajan and Jhingran, 1961). To find out the percentage volume, each food item was seperated under a dissection microscope. After microscopic examination, a list was compiled of all the types of food present, followed by a visual assessment of the percentage by volume that each food item constituted in the total amount present (Hobson, 1974).

4.3. RESULTS.

4.3.1. FEEDING INTENSITY

In general, most of the fishes were actively fed followed by moderately fed fishes both in Minicoy and Kalpeni samples. But more actively fed fishes were observed in the Minicoy samples when compared to that in the Kalpeni samples. The percentage of poorly fed fishes was relatively very low in both Minicoy and Kalpeni samples. The details regarding the feeding intensity in the different species are as follows:-

C.AURIGA Pl. 30

Except for the 20% fishes observed in December, 1988, poorly fed fishes were not observed during 1988 - 89 in the Minicoy samples. Only less than 10% of poorly fed fishes were observed in May and December, 1989 and February, 1990. In the Kalpeni samples, the percentage of poorly fed fishes was slightly greater than 10% during June, October, November and December, 1989.

C.LUNULA Pl. 30

In the Minicoy samples poorly fed fishes were observed during July, 1988 (25%) and March and june, 1989(less than 20%). In Kalpeni samples during April and October, 1989 all the fishes were found to be poorly fed and in September, 1989 it was above 75%.

C.XANTHOCEPHALUS Pl.31

In Minicoy 20% poorly fed fishes were observed only once (January 1990). Apart from that, the majority of the fishes were actively fed. In Kalpeni samples, all the fishes were poorly fed during July, September and November, 1989. 75% of the fishes were poorly fed during May 1989, 60% in March 1990, 50% in October 1989, 22% in February 1990 and 11% in December, 1989.

C.TRIFASCIATUS Pl. 31

All the fishes were poorly fed during October, 1989, above 70% in May, 1989, 60% in April, 1989, and February, 1990, 40% in December, 1989, above 30% in November, 1989 and around 25% in June, 1989 and January, 1990.

C.TRIFASCIALIS Pl. 31

The rate of feeding was moderate and no gorged and full stomachs were observed in the samples.

D.TRIMACULATUS Pl. 32

Only poorly fed fishes were encountered in August, 1989. 60% of the fishes were poorly fed in July, 1989 and nearly 10% during May and September, 1989 in the Minicoy samples. Poorly fed fishes were comparitively less in the Kalpeni samples, but were observed in low percentages during April, May, June and December 1989 and January and February 1990.

D.RETICULATUS Pl. 32

Poorly fed fishes were observed only twice (during July, 1989 - 50% and November,1989 - 5%) in the Minicoy samples. But poor feeding was observed during May (10%), June(nearly 45%), December, 1989 and January,1990(nearly

40%) and in February,1990(less than 10%) in the Kalpeni samples.

4.3.2.QUALITATIVE AND QUANTITATIVE ANALYSIS OF THE STOMACH CONTENTS

In both the stations, Minicoy and Kalpeni, the various food items observed in the stomach of *C.auriga*, *C.lunula* and *C.xanthocephalus* consisted of fish scales, amphipods, euphosids, copepods, cumaceans, serpulid worms, their tentacles and brood pouch, other polychaete worms, terebellid tentacles, polychaete larvae, sipunculid worms, invertebrate egg mass, *Obelia* fragments, seaanemones, Other hydroids, semidigested materials and plant materials. The plant materials include the diatom, *Skeletonema costatum* and the algae, *Codium* sp., *Gracilaria acerosa* and *Hypnea valentiae*. In *C.trifasciatus* the diet consisted of coral polyps, algae and semidigested materials. Only coral polyps were observed in the stomach of *C.trifascialis*. Major food items of chaetodons are shown in plate 33.

Since terebellid tentacles and seaanemones were found dominating by volume and all the other items, except the semidigested materials were comparitively insignificant in volume, the food items of chaetodons were classified into three major groups namely, terebellid tentacles, sea - anemones and other materials to show their difference in the monthly percentage occurence and volume as given in plates 34 - 36.

Eventhough the diet of chaetodons, except that of *C.trifasciatus* and *C.trifascialis*, comparised a variety of animal and plant materials, only terebellid tentacles and seaanemones were the dominant items and all the others were observed in negligible quantities. Thus in the case of *C.auriga* and *C.lunula*, terebellid tentacles ranked (1) in the annual index of preponderence of the various food items for the Minicoy samples during 1988 - 89 and seaanemones (2) (table 4.1 and 4.4) and during 1989 - '90 , sea anemones ranked first followed by terebellid tentacles (Table 4.2 and 4.5). The same result was observed for *C.auriga* in the Kalpeni samples also(Table 4.3). For *C.lunula* from Kalpeni sea anemones and the semidigested materials ranked (1) and (2) respectively and the terebellid tentacles had 3rd position (Table 4.6). For *C.xanthocephalus*, semidigested material was the dominating item and the terebellid tentacles and seaanemones ranked 2nd and 3rd respectively in both Minicoy and Kalpeni samples (Table 4.7 and 4.8). Coral polyps were the dominating food item of *C.trifasciatus*(Table 4.9).

The various food items observed in the stomachs of *D.trimaculatus* and *D.reticulatus* in both the stations were fish eggs, fish scales, bivalves, copepods, amphipods, decapods, isopods, mysids, *Lucifer* sp., ostracods, phyllosoma, zoea, cypris stage of *Balanus* sp., megalopa, other decapod larvae, serpulid brood pouch, polychaetes, polychaete larvae, invertebrate eggmass, seaanemones, *Obelia* fragments, siphonophores, other hydroids, digested materials and plant materials. The plant materials comprised the diatom, *Skeletonema costatum*, the algae, *Enteromorpha*

TABLE 4.1. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.AURIGA* FROM MINICOY DURING 1988 - '89

Sl. no.	Food items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rank
1	Terebellid tentacles			98.15	100	74.51	47.97	23.81	23.91	93.07	99.69	98.37	30.81	72.97	(1)
2	Polychaete worms			0.16					0.03				0.16	0.009	(8)
3	Seaanemones			0.65		13.78	29.5	33.5	72.07				0.001	16.45	(2)
4	Semidigested materials		99.9			8.48	22	31.3	3.18			0.23	67.96	10.06	(3)
5	Invertebrate eggmass							11.39	0.4	6.67		0.69	0.1	0.31	(4)
6	Serpulid worm												0.002	0.00001	(15)
7	Serpulid tentacles		0.1	0.03		0.003	0.02	0.003	0.01			0.22	0.16	0.031	(7)
8	Serpulid brood pouch						0.41					0.003	0.003	0.002	(9)
9	*Obelia* fragments								0.4	0.27	0.31	0.34	0.79	0.11	(5)
10	Amphipods											0.06	0.005	0.0004	(10)
11	Euphosids			0.003					0.01			0.01	0.001	0.0004	(10)
12	Copepod											0.003	0.001	0.00004	(12)
13	Cumacean												0.001	0.000004	(13)
14	Other hydroids												0.007	0.00004	(12)
15	Polychaete larvae												0.001	0.000004	(13)
16	Plant materials						0.01			0.001		0.08	0.008	0.002	(9)
17	Sipunclid introverts						0.02			0.001			0.001	0.0002	(11)
18	Sipunculid worm					3.22	0.06						0.001	0.058	(6)

TABLE 4.2. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.AURIGA* FROM MINICOY DURING 1989 - '90

Sl. no.	Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rank
1	Terebellid tentacles	91.7	33	14.6	37.1	17.6	66.41	48.1	37.2	27.6	25.11	61.4	5.16	41.73	(2)
2	Polychaete worms	0.13	0.08		0.23	0.03	0.02	0.01	0.01	0.12	0.01	0.08	0.03	0.075	(7)
3	Seaanemones		35.2	80.8	45.7	81.5	33.2	49.7	55.2	68.1	56.18	37.09	93.85	54.77	(1)
4	Semidigested material	7.04	29.6		16.6					3.62	18.5	0.94		2.49	(3)
5	Invertebrate eggmass		0.15	0.02	0	0.18	0.08	2.16	7.53	0.48	0.05	0.47	0.07	0.57	(4)
6	Serpulid worm	0.38		0.07		0	0.001			0	0.0005			0.01	(9)
7	Serpulid tentacles	0.75	0.01	0.21	0.22	0.43	0.03	0.01	0.01	0.01	0.01	0.01		0.1	(6)
8	Serpulid brood pouch	0.01	0.02	0.07	0	0.01	0.001	0	0.01	0	0.001	0.002		0.001	(13)
9	*Obelia* fragments	0.01	0.15	0.02	0.04	0	0.03	0.01	0.01	0.02	0.006	0.004	0.79	0.05	(8)
10	Amphipods		0		0		0.0004	0						0.0002	(14)
11	Euphosids		0				0.0004							0.0001	(15)
12	Copepod		0								0.0005			0.0001	(15)
13	Cumacean		0											0.00001	(16)
14	Other hydroids		0	0.1	0.01	0.01		0		0.01	0.0005	0.002		0.005	(10)
15	Polychaete larvae		0	0.02	0	0	0.001	0			0.02			0.002	(12)
16	Fish scales		0.1	0.03				0	0.01		0.05		0.07	0.01	(9)
17	Plant materials	0.01	0.19	0	0.01	0		0.01	0	0	0.002		0.03	0.01	(9)
18	Sipuncid introverts		0				0.005	0.05	0.01		0.02	0.002		0.004	(11)
19	Sipunculid worm		1.45	4.02	0	0.22	0.23	0		0	0.03			0.18	(15)

TABLE 4.3. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.AURIGA* FROM KALPENI DURING 1989 - '90

Sl.no.	Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rank
1	Terebellid tentacles	30.81	55.21	38.75	48.22	53.7	18.56	27.12	15.83	39.59	20.91	30.44	30.7	38.55	(2)
2	Polychaete worms	4.69	12.22	0.51	0.005	0.04		0.006	0.001	0.03		2.72	3.03	1.1	(6)
3	Seaanemones	0.94	8.31	7.11	45.97	44.28	64.23	66.57	77.56	29.79	41.82	61.99	59.23	44.82	(1)
4	Semidigested materials	60.45	14.31	30.02	1.36			1.01	0.28	26.3	34.76	3.74	4.02	9.38	(3)
5	Invertebrate eggmass	0.005	4.07	1.73	2.66	1.8	14.43	1.43	4.52	0.18	1.61	0.2	1.96	2.65	(5)
6	Serpulid worm	0.001			0.02									0.0003	(14)
7	Serpulid tentacles	0.001	2.55	0.28	0.01	0.02	1.65	0.004	0.02	0.01		0.44	0.07	0.35	(7)
8	Serpulid brood pouch		0.0003	0.01	0.001	0.001	0.002	0.001	0.001				0.001	0.001	(12)
9	*Obelia* fragments	0.03		0.03		0.001	0.002	0.0002	0.0005	0.002		0.03	0.04	0.01	(10)
10	Amphipods			0.001		0.001		0.0002	0.001					0.0001	(13)
11	Copepod		0.002		0.001	0.004								0.0001	(13)
12	Other hydroids	3.05	2.13	16.1	1.75	0.11	1.05	1.98	1.69	3.98	0.85	0.44	0.93	2.91	(4)
13	Polychaete larvae			0.2		0.04			0.0005					0.004	(11)
14	Fish scales		0.006	0.01										0.0001	(13)
15	Plant materials	0.001	0.01	0.05			0.04		0.0005				0.01	0.01	(10)
16	Sipuncid introverts						0.03	1.87	0.08	0.12		0.003	0.02	0.076	(9)
17	Sipunculid worm	0.02	1.19	5.18	0.002		0.002	0.001	0.03		0.04			0.15	(8)
18	Coral piece			0.01										0.0001	(13)
19	Decapod			0.003										0.00001	(15)
20	*Trochus*			0.003										0.00002	(14)

TABLE 4.4. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.LUNULA* FROM MINICOY DURING 1988 - '89

Sl.no.	Food Items	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Year	Rank
1	Terebellid tentacles	13.47	22.5	37.5	2.24	20	51.64	98.8	46.94	30.62	25.05	23.09	0.06	37.05	(1)
2	Polychaete worms											0.02		0.0001	(8)
3	Seaanemones	38.32			6.3	79.9	37.51		52.99	45.13	42.20	53.68	99.81	34.28	(2)
4	Semidigested materials	48.21	77.5	62.5	91.45		10.79			24.22	32.55	20.37		28.63	(2)
5	Invertebrate eggmass							1						0.01	(4)
6	Serpulid tentacles				0.01		0.02		0.01		0.02		0.06	0.01	(4)
7	Serpulid brood pouch								0.01	0.004	0.14		0.06	0.003	(5)
8	*Obelia* fragments						0.01	0.1	0.02	0.016	0.01	0.21		0.01	(4)
9	Amphipods							0.1				0.02		0.001	(6)
10	Euphosids											0.003		0.00001	(9)
11	Cumacean											0.003		0.00001	(9)
12	Other hydroids					0.1	0.02		0.03	0.02	0.02	0.003		0.01	(4)
13	Polychaete larvae											2.581		0.01	(4)
14	Plant materials											0.03		0.0002	(7)
15	Sipunculid worm						0.01		0.004					0.0002	(7)

TABLE 4.5. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.LUNULA* FROM MINICOY DURING 1989

Sl.no.	Food items	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Rank
1	Terebellid tentacles	50.07	7.18	4.98	0.24	5.01	26.55	40	20	17.86	(2)
2	Seaanemones	49.79	78.99	94.02	99.76	94.89	41.01	57	25	78.71	(1)
3	Semidigested materials		11.66				29.79			0.8	(4)
4	Serpulid tentacles	0.07	1.18	0.2		0.05	0.43	0.2	0.2	0.2	(5)
5	Serpulid brood pouch		0.01							0.0001	(12)
6	*Obelia* fragments	0.03	0.08			0.05			0.2	0.02	(7)
7	Amphipods							0.2		0.002	(10)
8	Other hydroids	0.03		0.8				0.2		0.03	(6)
9	Polychaete larvae		0.8				1.88	0.2	54.4	2.35	(3)
10	Fish scales							2		0.02	(7)
11	Plant materials		0.03				0.34	0.2		0.01	(8)
12	Sipuncid introverts								0.2	0.003	(9)
13	Sipunculid worm		0.08							0.001	(11)

TABLE 4.6. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.LUNULA* FROM KALPENI DURING 1989 - '90

Sl.no.	Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rank
1	Terebellid tentacles	0.59					2.34		52.53	33.46	42.64	43.44	23.69	11.6	(3)
2	Polychaete worms	0.43		23.61			0.12			0.01	3.92	0.02	1.75	1.03	(5)
3	Seaanemones	86.04	99.85		94.4		96.85		47.4	64.37	43.04	51.83	68.26	58.68	(1)
4	Semidigested materials	6.86		63.56		100		94.8		1.89	9.66	3.57	5.22	26.81	(2)
5	Serpulid worm										0.19			0.001	(12)
6	Serpulid tentacles	0.1	0.03	3.75	4				0.01			0.24	0.11	0.365	(7)
7	Serpulid brood pouch				1				0.005				0.04	0.02	(10)
8	*Obelia* fragments	0.08	0.05	0.12	0.2				0.01	0.04		0.03		0.04	(9)
9	Amphipods						0.02				0.04	0.004		0.001	(12)
10	Other hydroids	5.91	0.07	0.12	0.2		0.09	5	0.05	0.19	0.36	0.84	0.57	1.22	(4)
11	Polychaete larvae			5.05	0.2		0.09	0.2		0.04	0.15	0.05	0.35	0.46	(6)
12	Fish scales			3.75			0.28							0.09	(8)
13	Plant materials			0.03			0.21							0.004	(11)

TABLE 4.7. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.XANTHOCEPHALUS* FROM MINICOY DURING MAY 1989 TO JAN 1990

Sl.no.	Food Items	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Year	Rank
1	Terebellid tentacles				22.15	21.66	1	4.59	85.72		11.331 (2)	
2	Seaanemones				18.93	12.78		42.7		10.03	5.38 (3)	
3	Semidigested materials	94	99.93	99.93	58.71	65.55	98.75			89.75	80.03 (1)	
4	Serpulid tentacles				0.19			52.71		0.1	1.44 (5)	
5	*Obelia*	4	0.02	0.04	0.02	0.01	0.05			0.02	0.27 (6)	
6	Other hydroids		0.05	0.03	0.001		0.2		14.28		1.517 (4)	
7	Plant materials	2									0.03 (7)	
8	Sipunclid introverts									0.1	0.002 (8)	

TABLE 4.8. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.XANTHOCEPHALUS* FROM KALPENI DURING 1989 - '90

Sl.no.	Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Feb	Mar	Year	Rank
1	Terebellid Tentacles	0.94	0.1		3.78	98.8				32.2	46.05	12.08		9.02	(3)
2	Polychaete worms					0.2				0.05		0.003		0.01	(8)
3	Sea Anemones	5.84			28.3				50	39.42	47.64	86.8	99.55	23.4	(2)
4	Semidigested Materials	92.92	93.2	100			100	99.8	50	25.43	6	0.9		64.82	(1)
5	Invertebrate egg mass	0.12	1.34								0.02			0.03	(6)
6	Serpulid Worm									0.03				0.0002	(10)
7	Serpulid Tentacles									2.52	0.003			0.02	(7)
8	Seroulid brood pouch	0.01												0.00004	(11)
9	*Obelia* fragments	0.11										0.01		0.001	(9)
10	Amphipods		0.02											0.0002	(10)
11	OtherHydroids	0.01			49.05	1		0.2		0.35	0.13	0.19		1.11	(5)
12	Plant materials	0.05	5.37		18.87						0.16	0.02	0.45	1.76	(4)

TABLE 4.9. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.TRIFASCIATUS* FROM KALPENI DURING 1989 - '90

Sl.no.	Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Feb	Mar	Year	Rank
1	Coral Polyps			100	100	100	100	100	100	100	75.39	100	100	94.7071	(1)
2	Semidigested Materials	99.96	100								24.61			5.2925	(2)
3	Plant materials	0.04												0.0004	(3)

compressa , *Rhizoclonium* sp., *Hypnea valentiae*, *Polysiphonia* sp., *Ceraminum* sp, *Oscillatoria* and *Lyngbya* sp..

Among the various food items, copepods and plant materials were found to be dominating and the other items were insignificant in their relative volumes. Hence to show their differences in percentage occurence and volume, the food items were grouped into three major items namely, copepods, other animal materials and plant materials as given in plates 37 and 38.

Copepods ranked (1) in *D.trimaculatus* and in *D.reticulatus* from both the stations and plant materials ranked (2) except in *D.trimaculatus* from Minicoy and Kalpeni 1989 - '90 and in *D.reticulatus* from Minicoy and Kalpeni, in which the digested materials ranked (2) as shown in Tables 4.10 - 4.14.

4.4.DISCUSSION

The comparatively greater occurrence of actively and moderately fed fishes indicates that food was available in sufficient quantities in the Minicoy and Kalpeni lagoons. However, the following reasons are suggested to explain the occurence of poorly fed fishes in these waters, in some months.

1. Birkland and Neudecker(1981) classified some chaetodons as "active generalists" as they feed on a varied diet and when a prey is particularly common it is taken less than expected by chance and when the same prey is

TABLE 4.10. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *C.TRIMACULATUS* FROM MINICOY DURING 1988 -'89

Sl.no	Food Items	Oct.	Nov.	Dec.	Jan	Feb	Mar	Year	Rank
1	Copepod	94.21	95.88	79.79	92.8	78.39	98.06	93.65	(1)
2	Ostracode		0.01	0.02	0.03			0.01	(11)
3	*Oscillatoria* sp.	5.17	1.66	11.08	3.78	20.25		4.72	(2)
4	*Lyngbya* Sp.		1.78	5	2.9			0.79	(3)
5	*Skeletonema costatum*		0.09	2.06				0.08	(6)
6	*Obelia* fragments					0.2		0.004	(13)
7	Polychaete	0.12					0.01	0.01	(11)
8	Siphonophores	0.31	0.45	1.85	0.25		0.37	0.43	(4)
9	Decapod larvae	0.07	0.04	0.08	0.06	0.2	0.23	0.11	(5)
10	Fish scales	0.07	0.01	0.1	0.02	0.2	0.06	0.07	(7)
11	Cypris stage of *Balanus* sp.	0.03	0.08		0.12		0.01	0.03	(10)
12	Fish eggs		0.005	0.02	0.02	0.56	0.01	0.04	(9)
13	Mysids						0.002	0.0001	(14)
14	Chaetognaths						0.002	0.0001	(14)
15	Amphipod					0.2	0.002	0.0059	(12)
16	Digested materials						1.234	0.0499	(8)

TABLE 4.11. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *D. TRIMACULATUS* FROM MINICOY DURING 1989 - '90

Sl.no.	Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rank
1	Copepods	99.81	44.43	7.02	93.75	90	55.5	37.3	85.95	41.24	40.18	45.65	35	80.95	(1)
2	Ostracods							0.003	0.01	0.001	0.001			0.001	(15)
3	*Oscillatoria* sp.		32.96	74.87		5		5.76	0.01		0.001			3.82	(4)
4	*Ceramium* sp.								2.17					0.04	(10)
5	*Skeletonema costatum*						0.005		0.13	0.034	0.046	0.07	0.2	0.03	(11)
6	*Enteromorpha compressa*						42.39	56.22		49.384	48.085			4.9	(3)
7	*Polysiphonia* sp.								0.01		0.01			0.001	(15)
8	*Hypnea valentiae*						0.18	0.003		0.869	1.29	1.11	0.2	0.4	(7)
9	*Obelia* sp.					5	0.02	0.02		0.002	0.001			0.11	(9)
10	Polychaete						0.005	0.001		0.565	0.22			0.01	(13)
11	Invertebrate eggmass		0.01	0.06			0.005			0.01		0.04		0.002	(14)
12	Siphonophores	0.19	0.01	0.56	6.25		0.02				0.02	0.07	40	2.65	(5)
13	Decapod larvae		0.04	0.1			0.09	0.03		0.001	0.003	0.07		0.11	(13)
14	Fish scales		0.99	2.62			0.03	0.01		0.044	1.32			0.26	(8)
15	Cypris stage of *Balanus* sp.		0.11	0.08			0.02	0.13		0.001	0.14			0.02	(12)
16	Fish eggs		0.01	0.02			0.06	0.07		0.279	0.02	0.19		0.03	(11)
17	Megalopa			0.01			0.005							0.0002	(17)
18	Digested materials		21.45	14.6			1.68	0.45		5.43	3.46	47.04	24.6	6.17	(2)
19	Other hydroids									2.14	5.19	0.18		0.57	(6)
20	Amphipods			0.06			0.02	0.001			0.01			0.0008	(16)
21	Bivalves										0.001			0.00002	(18)
22	Decapods										0.002			0.00001	(19)
23	Polychaete larvae											5.58		0.03	(11)

TABLE 4.12. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *D. TRIMACULATUS* FROM KALPENI DURING 1989 - '90

Sl.no.	Food items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rank
1	Copepods	42.48	65.05	35.27	91.02	95.44	87.21	34	91.03	56.94	69.26	36.1	50.21	82.17	(1)
2	Ostracods	0.001	0.002		0.06	0.16	0.22	0.01	0.05	0.001	0.01	0.001		0.02	(12)
3	*Oscillatoria* sp.	53.686	34.77	61.14	7.11		0.56				0.002	0.001		6.82	(3)
4	*Skeletonema costatum*							59.36		0.43	0.32	0.14		1.42	(4)
5	Enteromorpha compressa				0.61	3.46		5.07	8.64	0.003	0.06	0.001		0.71	(5)
6	*Hypnea valentiae*	0.02		0.2	0.02				0.016	0.1	0.372	0.5		0.06	(9)
7	*Ceramium* sp.						11.21			0.001	0.16	0.3		0.12	(7)
8	*Polysiphonia* sp.										0.001	0.001	0.02	0.001	(17)
9	*Obelia* sp.	0.001	0.002	0.021	0.02		0.06			0.001	0.01			0.004	(14)
10	Polychaetes	0.01	0.001			0.005				0.004	0.01	0.001	0.09	0.005	(13)
11	Invertebrate eggmass	0.001	0.0003			0.005	0.06			0.01				0.001	(17)
12	Serpulid brood pouch	0.001									0.001			0.00001	(19)
13	Siphonophores	0.1	0.093	0.003	0.32	0.29	0.22		0.09	0.002		0.01		0.06	(9)
14	Decapod larvae	0.01	0.06		0.14	0.04	0.22	0.04	0.002	0.02	0.01	0.002		0.03	(11)
15	Fish scales	0.001	0.01	0.01	0.06	0.005	0.06	0.02	0.002	0.25	0.002	0.001	0.02	0.07	(8)
16	Cypris stage of *Balanus* sp.			0.01	0.49	0.21	0.06	0.04	0.17	0.05	0.05	0.06	0.1	0.07	(8)
17	Fish eggs	0.01			0.02	0.005	0.06	0.01		0.001	0.02			0.005	(13)
18	Megalopa		0.008	0.003							0.001			0.003	(15)
19	Zoea	0.001	0.0003							0.001				0.0001	(18)
20	Hydroids	0.136	0.0014					1.44		0.24	0.26	0.58	0.45	2.6	(6)
21	Amphipods	0.006	0.0003		0.02		0.06			0.005	0.001	0.001		0.002	(16)
22	Digested materials	3.531	0.0014			0.38				41.92	29.25	62.3	49.11	8.1	(2)
23	*Lucifer* sp.	0.002		0.003	0.03									0.001	(16)
24	Decapods	0.002	0.0003	3.34	0.06			0.01		0.02	0.2	0.001		0.02	(12)
25	Mysids	0.001												0.04	(10)
26	Seaanemone				0.02									0.0001	(18)
27	Phyllosoma larva									0.001				0.00001	(19)

TABLE 4.13. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *D.RETICULATUS* FROM MINICOY DURING 1989 - '90

Sl.no.	Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Feb.	Mar.	Year	Rank
1	Copepods	99.4	54.11	8.82	58.48	39.41	61.13	34.48	37.46	54.6	7.75	98.78	29.13	71.6	(1)
2	Ostracode				0.4			0.0005	0.04	0.01	0.001			0.002	(14)
3	*Skeletonema costatum*				0.02				1.15	0.032	0.21		0.02	0.033	(10)
4	*Oscillatoria* sp.	0.2	45.63		40.81	21.96	38.62	0.001	0.24	0.001	0.006			8.86	(3)
5	*Enteromorpha compressa*							4.588	0.001					0.04	(8)
6	*Hypnea valentiae*								2.7	0.231	3.4	1.11	0.34	0.399	(9)
7	*Ceramium* sp.			90.85	0.1				0.62	0.081	38.53			3.13	(4)
8	*Polysiphonia* sp.			0.05					2.28	0.001	0.03		0.08	0.04	(8)
9	*Obelia* sp.	0.2	0.05	0.03	0.07	0.02	0.07	0.002	0.01		0.004		0.02	0.04	(8)
10	Polychaete					0.01		0.08	0.86	0.85	0.51	0.05	0.15	0.13	(6)
11	Invertebrate eggmass		0.02					0.0005	0.12		0.001			0.01	(13)
12	Siphonophores		0.08	0.1	0.03	0.02	0.05				0.001			0.015	(12)
13	Decapod Larvae		0.01	0.07	0.01	0.02	0.03	0.0029	0.001		0.006			0.01	(13)
14	Fish scales		0.002	0.07		0.02	0.002	0.0044	0.027	0.002	0.06			0.01	(13)
15	Cypris stage of *Balanus* sp	0.2	0.098	0.01	0.07	0.03	0.098	0.11	0.12	0.022	0.24			0.07	(7)
16	Fish eggs				0.01	0.02		0.0005	0.11	0.03	1.12			0.03	(11)
17	Other hydroids								39.19	17.34	14.95		1.86	1.76	(5)
18	Digested materials					38.49		60.73	15.07	26.8	33.18	0.05	68.4	13.82	(2)
19	Zoea							0.0001						0.000001	(16)
20	Amphipods							0.0001	0.001		0.001	0.01		0.001	(15)

TABLE 4.14. MONTHLY AND ANNUAL INDEX OF PREPONDERENCE OF VARIOUS FOOD ITEMS OF *D.RETICULATUS* FROM KALPENI DURING 1989 - '90

Sl.no.	Food Items	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Year	Rank
1	Copepods	4.66	63.353	56.07	66.62	87.34	69.4	60.07	21.72	59.22	43.22	56.36	42.04	75.0167	(1)
2	Ostracode		0.001		0.014	0.07	0.08	0.03	0.15	0.001	0.009	0.014		0.01	(12)
3	*Skeletonema costatum*					0.001		12.18		0.361	0.324	0.167	0.23	0.72	(5)
4	*Oscillatoria* sp.	95.17	36.033	43.92	0.014		0.38			0.12	0.094	0.003	0.02	8.89	(3)
5	*Enteromorpha compressa*				31.55	11.46	29.73	12.05			0.042	0.014		2.76	(4)
6	*Hypnea valentiae*										0.381	0.106	0.67	0.04	(9)
7	*Ceramium* sp.									0.032		0.012	20.32	0.7	(6)
8	*Polysiphonia* sp.									0.001	0.002	0.005		0.00012	(20)
9	*Obelia* sp.	0.002	0.004	0.005		0.005				0.001		0.0002		0.001	(16)
10	Polychaete	0.001	0.009											0.0002	(19)
11	Invertebrate eggmass	0.241				0.062		0.01				0.11		0.005	(14)
12	Siphonophores	0.002	0.139		0.05	0.16	0.05			0.003		0.0001		0.018	(11)
13	Decapod larvae		0.0069		0.03	0.04	0.01	0.01		0.01	0.002	0.0001		0.006	(13)
14	Fish scales	0.0001	0.0073	0.001		0.005				0.001	0.002	0.0002		0.0007	(17)
15	Cypris stage of *Balanus* sp.	0.13	0.12	0.003	0.33	0.56	0.25	0.1	0.53	0.004		0.037	0.04	0.144	(7)
16	Fish eggs	0.01		0.001	0.014	0.019	0.1	0.01		0.004	1.73	0.0001		0.103	(8)
17	Other hydroids									0.231	0.161	0.45	0.12	0.03	(10)
18	Amphipods	0.0001	0.0004		0.004	0.001				0.001	0.002	0.0001		0.001	(16)
19	Serpulid brood pouch	0.0007												0.00001	(21)
20	Decapod									0.004	0.126	0.032		0.004	(15)
21	Digested materials		0.3264		1.37	0.233		15.47	77.6	39.96	53.91	42.77	36.55	11.54	(2)
22	Isopods				0.004	0.044		0.07		0.043	0.005	0.018		0.01	(12)
23	Megalopa									0.1003		0.0001	0.01	0.00026	(18)
24	Zoea	0.0007										0.0001		0.00001	(21)

relatively scarce, it is taken more than expected. Hence poor feeding rate in the case of chaetodons may not be accounted for the scarcity of food materials in the lagoons, instead, it might be due to this specific behavioural pattern of these fishes,

2. chaetodons are oppurtunists in feeding behaviour (Ralston, 1981) and they greatly depend on the tubicolous polychaetes for their diet. Hence their poor feeding may be taken on account of the exposure of these animals from their resident tubes rather than the non-availability of sufficient food materials in the lagoons,

3. in the case of pomacentrids, they may have to compete with their resident corals, as corals are also zooplankton feeders,

4. poor feeding of the fishes during June, July and August may be due to the unfavourable environmental conditions characteristic of the moonsoon seasons. Ralston (1981) also reported diet of chaetodons showing significant variation according to seasons, locality and size of fish,

5. low feeding rate may be associated with the spawning time of these fishes,

6. both chaetodons and pomacentrids are diurnal in habits. Poorly fed fishes might have occurred in the samples collected in the early morning hours. Significantly

higher feeding rate in *C.triafacialis* during early afternoon has been reported by Irons (1989) and

7. destruction and depletion of corals due to environmental damages, both natual and man-made (James *et al.* 1989), caused depletion of sedentary preys and scarcity of shelter for the coral reef fishes. Hence the scarcity of food in the lagoon environment may not be neglected as a reason for the poor feeding of the fishes, especially that of *C.trifasciatus* and *C.trifascialis* which are obligate coral feeders. Reese(1981) described these fishes as indicator species, the absence of which indicate changes occuring to reef. The disappearence of live coral in the Minicoy lagoon is evidenced by the plate 28.

The chaetodons may be broadly divided into coelenterate predators, carnivors, preying upon other benthic invertebrates, omnivores and plankton feeders (Hiatt - Strasburg 1960, Randall 1967, Hobson 1974, Anderson *et al.* 1981, Harmelin - Viven and Bouchon - Navaro 1982, 1983). According to Harmelin - Viven and Bouchon - Navaro(1983), and Harmelin - Viven(1989), the chaetodontids can be divided into two readliy distinguishable groups; the obligate coral feeders(*C.trifasciatus* and *C.trifascialis*)which are preying exclusively upon scleractinian polyps and non-obligate or facultative coral feeders(*C.auriga, C.citrinellus, C.kleini, C.lunula, C.madagaskariensis, C.vagbundus* and *C.xanthocephalus*), which feed on coral polyps together with many other benthic organisms, from algae to ascidians.

The present study showed that *C.trifascialis* and *C.trifasciatus* are obligate coral feeders, preying on coral polyps. Many authors (Reese 1975,1977, 1981, Irons 1989) have reported the coral feeding habit of these fishes. Motta (1985 and 1988) described the dentition of *C.trifascialis* and *C.trifasciatus* suitable for preying on coral polyps. *C.trifascialis* as obligate coral feeder is also reported by Ralston (1981). In the present study also it was observed that *C.auriga, C.lunula* and *C.xanthocephalus* are benthic, but non-obligate coral feeders, in which tentacles of sedentry polychaetes and seaanemones were the preferred prey items. Sano (1989) reported *C.auriga* and *C.lunula* feeding on a wide variety of benthic organisms namely algae, seaanemones, sedentary polychaetes such as terebellids, serpulids and sabellids, sponges and hydroids. Motta (1985) described *C.auriga* as a benthic omnivore feeding or non-coralline and coralline invertebrates with preference for alcyonarians, polychaetes, scleractinians and algae. Pillai *et al.*(1992)reported filmentous algae, copepods , seaanemones and sand particles as the major food items of *C.auriga* and filamentous algae,anthozoans, polychaetes and sponges as that of *C.lunula* from Minicoy lagoon. However somewhat different observation was made by Vijay Anand (1994). He reported the dominance of coral polyps in the food of *C.auriga,* along with filamentous algae, amphipods, sponges and sipunculids. He also reported polychaete tentacles, algae, polyps, amphipods, decapod larvae, copepods, molluscs and eggs in the stomach of *C.lunula*; coral polyps, polychaetes and filamentous algae in *C.trifascialis*; the preferred food item of *C.trifasciatus* as polychaete tentacles and algae as the dominating food of *C.xanthocephalus*.

The importance of seaanemones as a significant prey among the chaetodons has not been recognised in Marshall Islands (Hiatt and Strasburg 1960), Caribbean (Randall 1967), Hawaii(Hobson 1974), Red sea (Harmelin - Vivien and Bouchon - Navaro 1982) or French Polynasia(Harmelin - Vivien and Bouchon - Navaro 1983). But Sano *et al.* (1984b) and Sano (1989) reported seaanemones as an important diet of the non-coralline invertebrate feeder butterfly fishes of Japan. They have suggested that this may be due to the greater abundance of this particular prey in the concerned areas.

According to Birkland and Neudecker (1981) the variety in diet of chaetodontids is to augment the diet with essential nutrients, as the discrete food items like polychaetes, eggs and crustaceans were probably of higher calorific value and anthozoans generally have a much lower calorific value. He further explained that, since individual food items usually do not contain all the essential kinds of macromolecules, the chaetodontids may need to eat at least small amounts of several food items to survive.

The two damsel fishes, *D.trimaculatus* and *D.reticulatus* were found to be mainly zooplankton feeders, with a preference for copepodes. This zooplanktivorous nature of these two pomacentrids agrees with the zooplankton feeding habits of other pomacentrids. Several pomacentrids such as *Chromis* and *Pomacentrus* are reported to be zooplankton feeders (Hiatt and Strasburg 1960, Madan mohan *et al.* 1986b). Other pomacentrids such as *Dascyllus* are particulate zooplankton feeders (Hiatt and Strasburg 1960), feeding on lagoon plankton including copepods and amphipods (Pillai *et al.* 1985a). Vijay Anand (1994) reported copepods, fish larvae, eggs, decapod larvae, medusae, polychaetes, shrimps, ostracods, amphipods, chaetognaths and molluscan larvae comprising the diet of *D.trimaculatus* and *D.reticulatus*. Some *Pomacentrus* spp. are described as facultative omnivores feeding equally on algae and zooplankton (Goldman and Talbot 1976). The present study also agrees with this observation, as *D.trimaculatus* and *D.reticulatus* were found to be feeding almost equally on zooplankton and algae. Hence these two pomacentrids could also be considered as facultative omnivores. Lassuy (1984) reported *Polysiphonia* spp., *Ceramium* spp. and *Enteromorpha* sp. in the stomach of the damselfish, *Stegastes lividus* and Montgomery (1980) also reported feeding of herbivores damselfish *Eupomacentrus rectifraenum* and *Microspathodon dorsalis* on *Polysiphonia* sp. Sammarco (1983) experimentally proved grazing of the pomacentrid, *Hemiglyphidodon plagimetopon* on algal community consisting of rhodophytes and cyanophytes which include *Polysiphonia* sp., *Lyngbya* sp. and *Oscillatoria* spp. As these food items were found in the stomach of *D.trimaculatus* and *D.reticulatus* also it could be deduced that omnivorous feeding may be a common characteristic of these two pomacentrid fishes.

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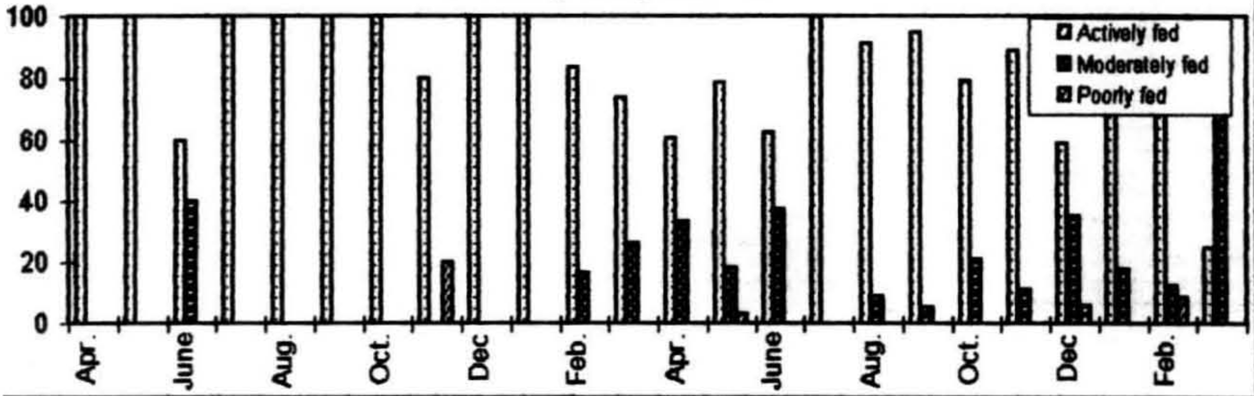
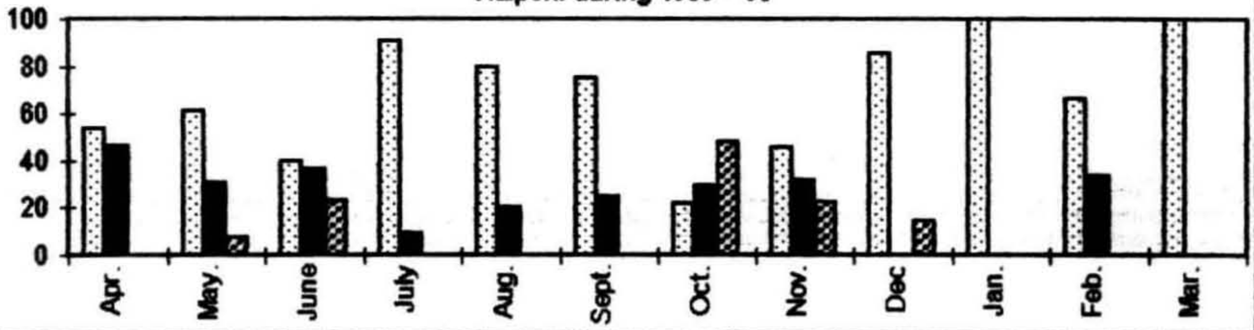
PLATE. 30.

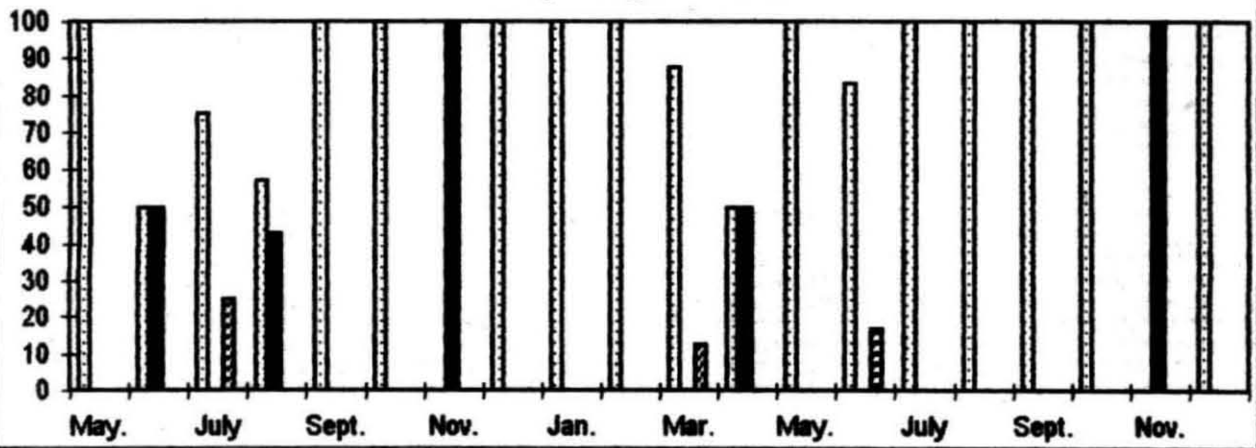
I. Monthly percentage of Actively, Moderately and Poorly fed *c.auriga* from Minicoy during 1988 - '90



II. Monthly percentage of Actively, Moderately and Poorly fed *C.auriga* from Kalpeni during 1989 - '90



III. Monthly percenatge of Actively, Moderately and Poorly fed *C.lunula* from Minicoy during 1988 - 1989



IV. Monthly percentage of Actively, Moderately and Poorly fed *C.lunula* from Kalpeni during 1989 - '90

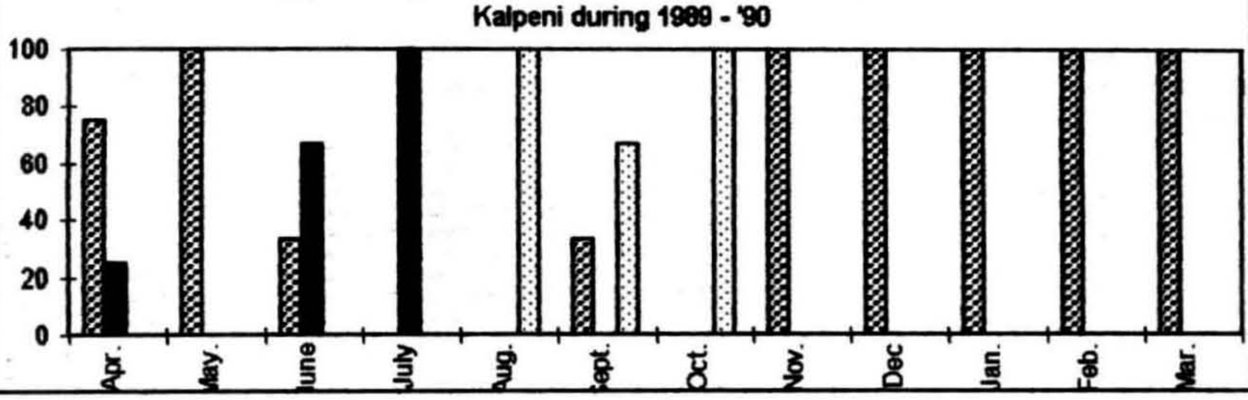


PLATE. 31.

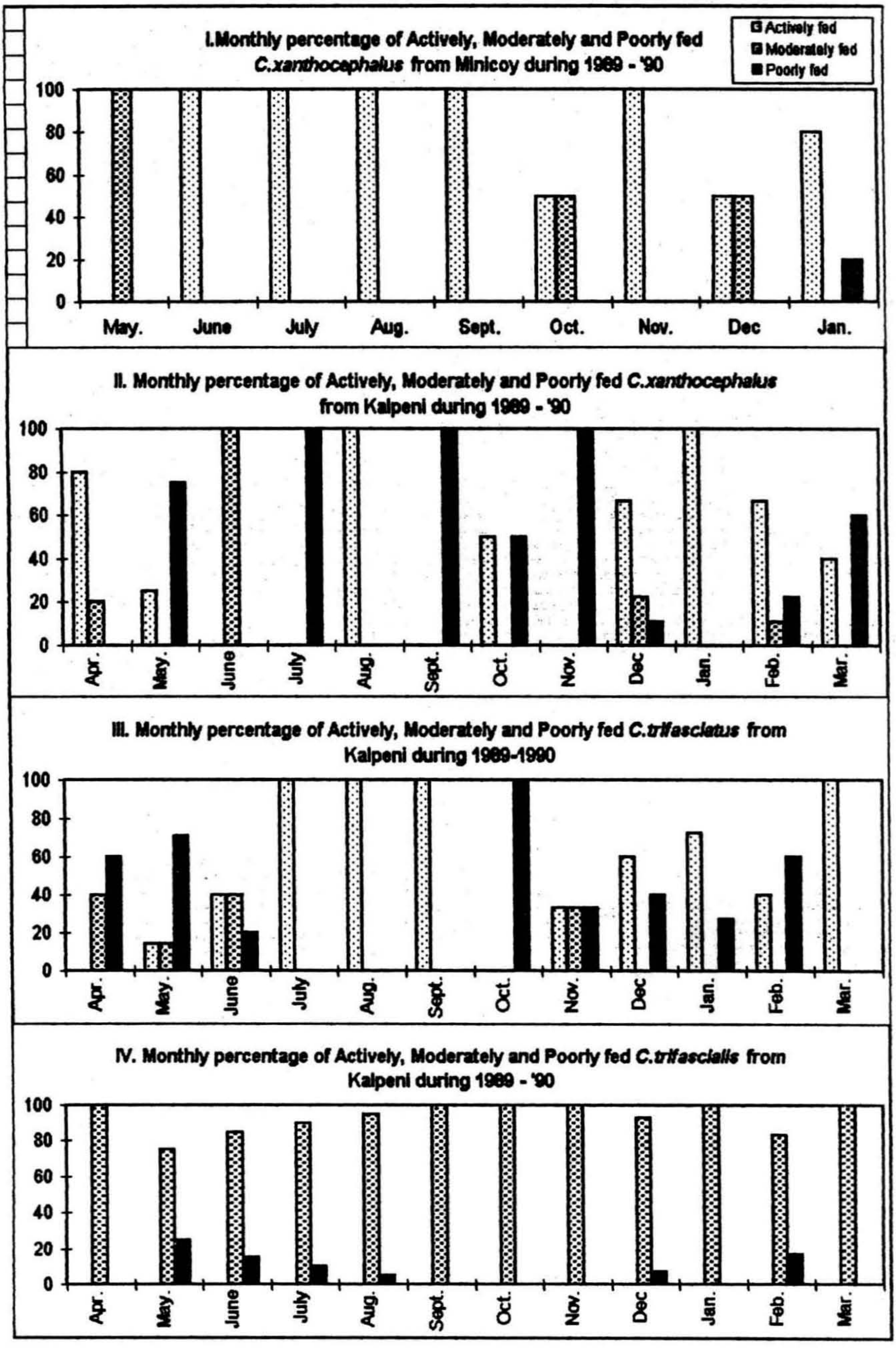
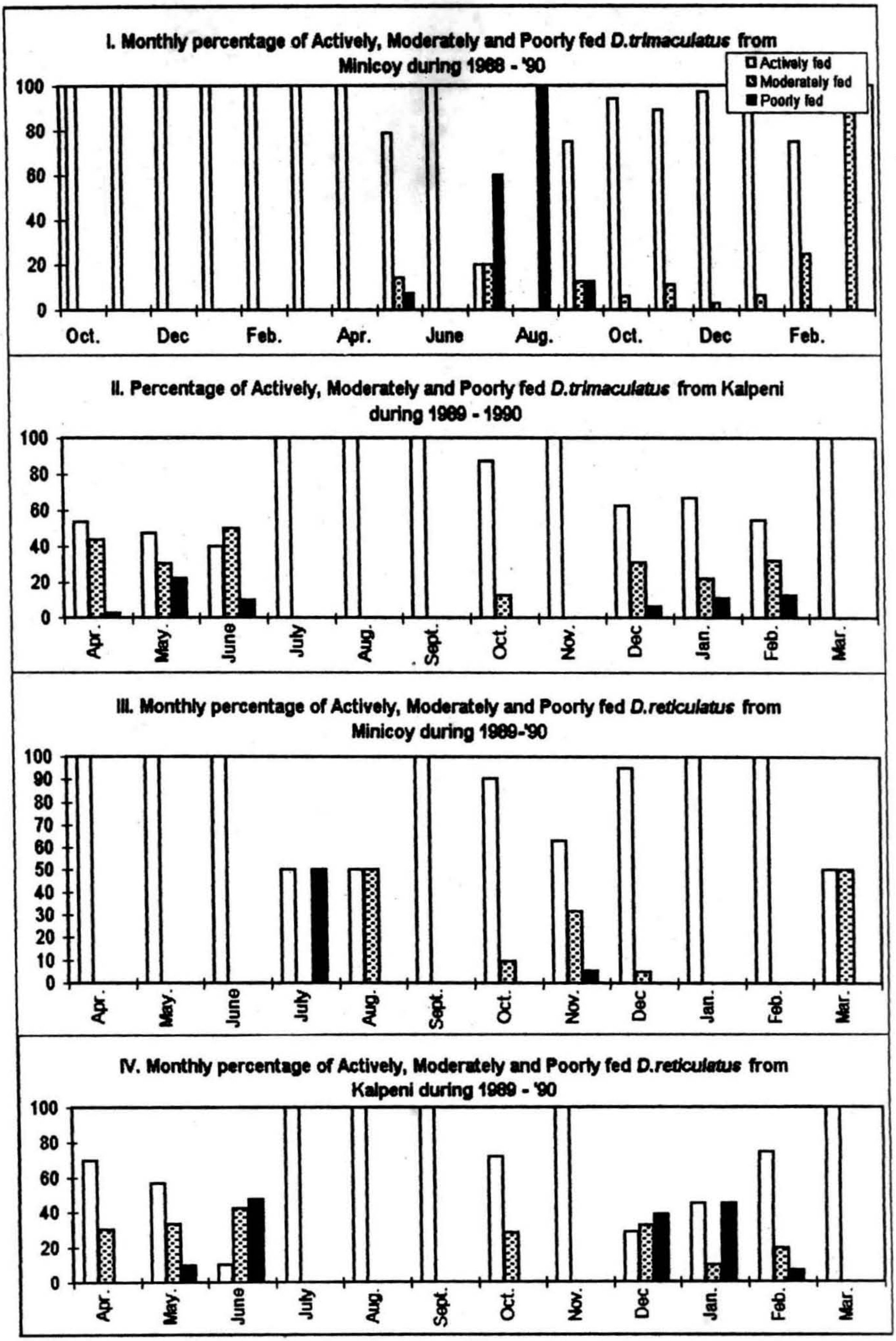
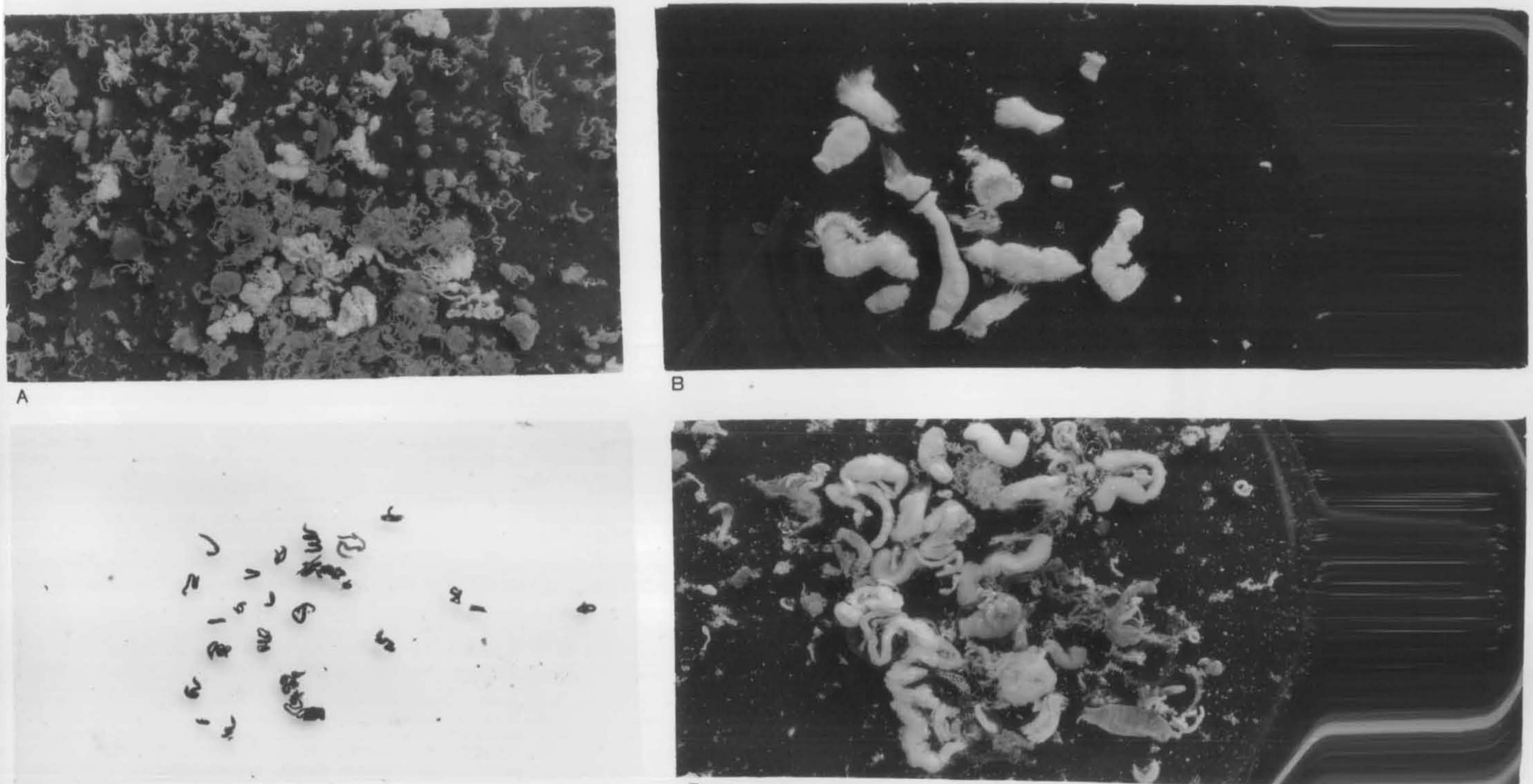

Actively fed
Moderately fed
Poorly fed
I.Monthly percentage of Actively, Moderately and Poorly fed C.xanthocephalus from Minicoy during 1989 - '90
100
80
60
40
20
0
May.
June
July
Aug.
Sept.
Oct.
Nov.
Dec
Jan.
II. Monthly percentage of Actively, Moderately and Poorly fed C.xanthocephalus from Kalpeni during 1989 - '90
100
80
60
40
20
0
Apr.
May.
June
July
Aug.
Sept.
Oct.
Nov.
Dec
Jan.
Feb.
Mar.
III. Monthly percentage of Actively, Moderately and Poorly fed C.trifasciatus from Kalpeni during 1989-1990
100
80
60
40
20
0
Apr.
May.
June
July
Aug.
Sept.
Oct.
Nov.
Dec
Jan.
Feb.
Mar.
IV. Monthly percentage of Actively, Moderately and Poorly fed C.trifascialis from Kalpeni during 1989 - '90
100
80
60
40
20
0
Apr.
May.
June
July
Aug.
Sept.
Oct.
Nov.
Dec
Jan.
Feb.
Mar.

PLATE.32.


I. Monthly percentage of Actively, Moderately and Poorly fed D.trimaculatus from Minicoy during 1988 - '90
Actively fed
Moderately fed
Poorly fed
100
80
60
40
20
0
Oct.
Dec
Feb.
Apr.
June
Aug.
Oct.
Dec
Feb.
II. Percentage of Actively, Moderately and Poorly fed D.trimaculatus from Kalpeni during 1989 - 1990
100
80
60
40
20
0
Apr.
May.
June
July
Aug.
Sept.
Oct.
Nov.
Dec
Jan.
Feb.
Mar.
III. Monthly percentage of Actively, Moderately and Poorly fed D.reticulatus from Minicoy during 1989-'90
100
90
80
70
60
50
40
30
20
10
0
Apr.
May.
June
July
Aug.
Sept.
Oct.
Nov.
Dec
Jan.
Feb.
Mar.
IV. Monthly percentage of Actively, Moderately and Poorly fed D.reticulatus from Kalpeni during 1989 - '90
100
80
60
40
20
0
Apr.
May.
June
July
Aug.
Sept.
Oct.
Nov.
Dec
Jan.
Feb.
Mar.



A B C D

Food items of C. auriga. A. Terebellid tentacles. B. Sea anemones. C. Polychaete worms. D. Sipunculid worms.

PLATE.34.

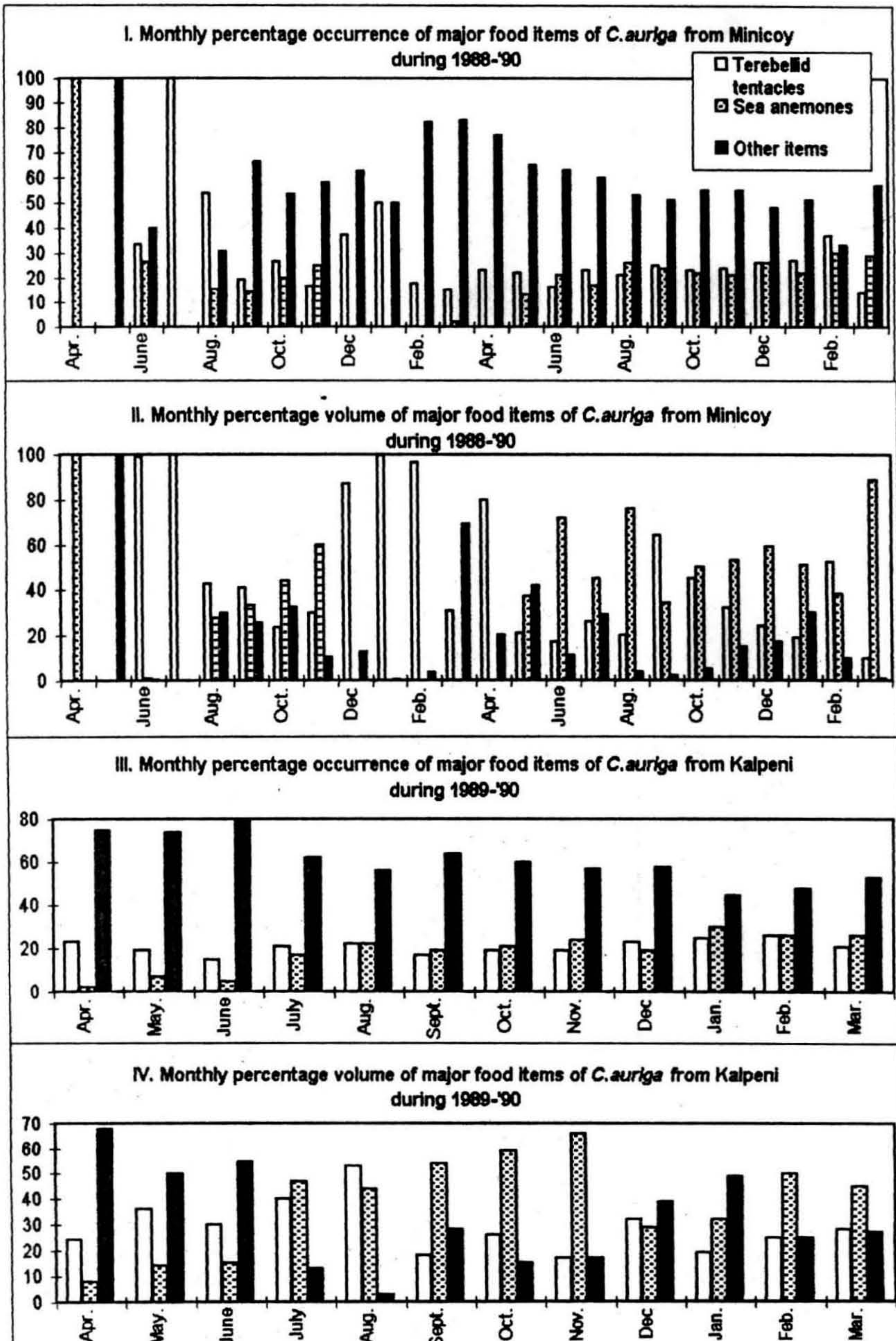
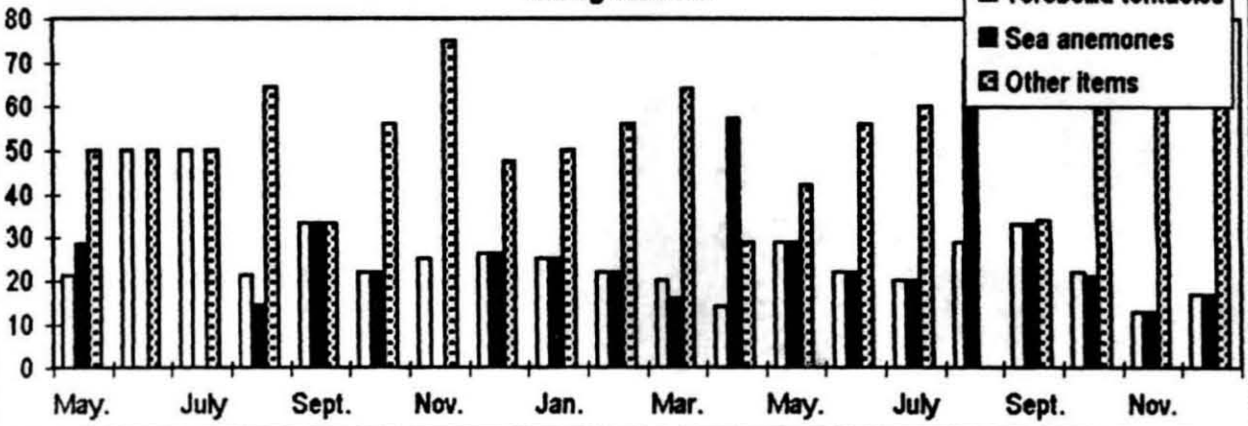
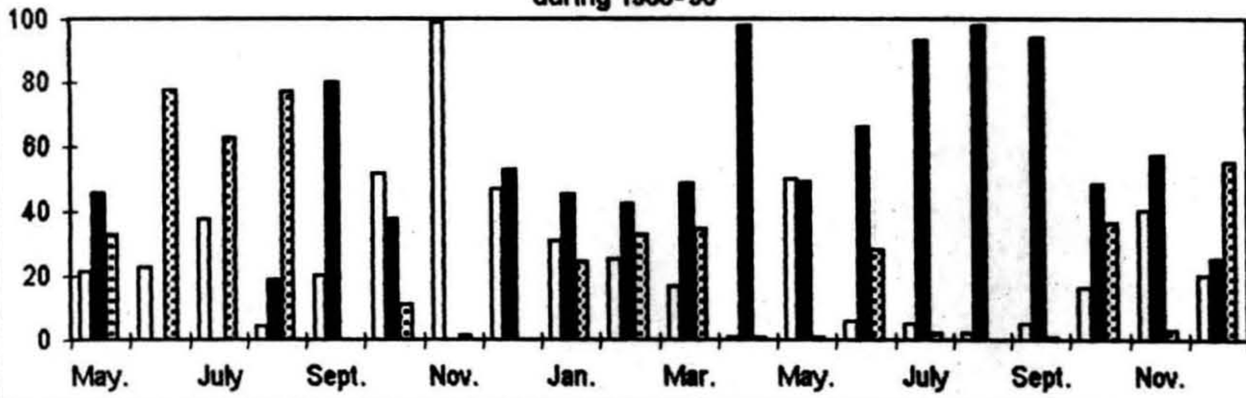

I. Monthly percentage occurrence of major food items of C.auriga from Minicoy during 1988-'90
Terebellid tentacles
Sea anemones
Other items
100 90 80 70 60 50 40 30 20 10 0
Apr. June Aug. Oct. Dec Feb. Apr. June Aug. Oct. Dec Feb.
II. Monthly percentage volume of major food items of C.auriga from Minicoy during 1988-'90
100 80 60 40 20 0
Apr. June Aug. Oct. Dec Feb. Apr. June Aug. Oct. Dec Feb.
III. Monthly percentage occurrence of major food items of C.auriga from Kalpeni during 1989-'90
80 60 40 20 0
Apr. May. June July Aug. Sept. Oct. Nov. Dec Jan. Feb. Mar.
IV. Monthly percentage volume of major food items of C.auriga from Kalpeni during 1989-'90
70 60 50 40 30 20 10 0
Apr. May. June July Aug. Sept. Oct. Nov. Dec Jan. Feb. Mar.

PLATE 35

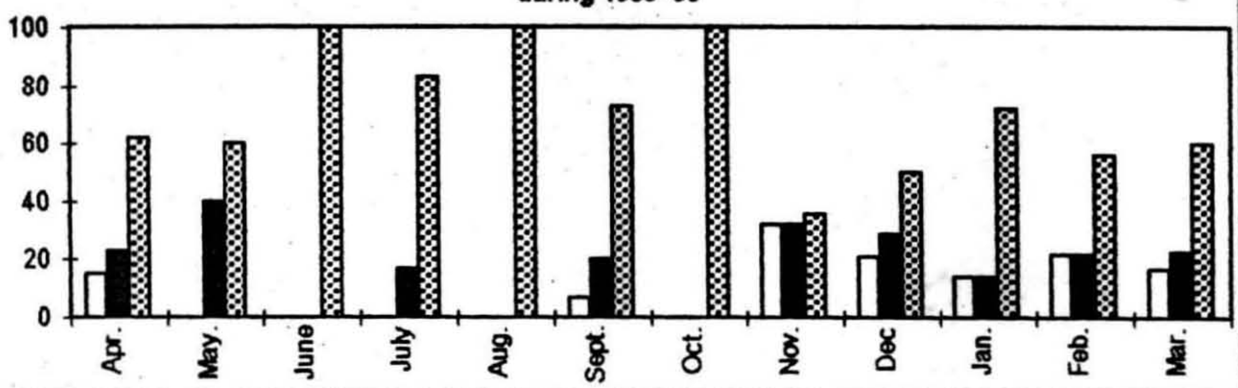
I. Monthly percentage occurrence of major food items of *C.lunula* from Minicoy during 1988-'90



II. Monthly percentage volume of major food items of *C.lunula* from Minicoy during 1988-'90



III. Monthly percentage occurrence of major food items of *C.lunula* from Kalpeni during 1989-'90



IV. Monthly percentage volume of major food items of *C.lunula* from Kalpeni during 1989-'90

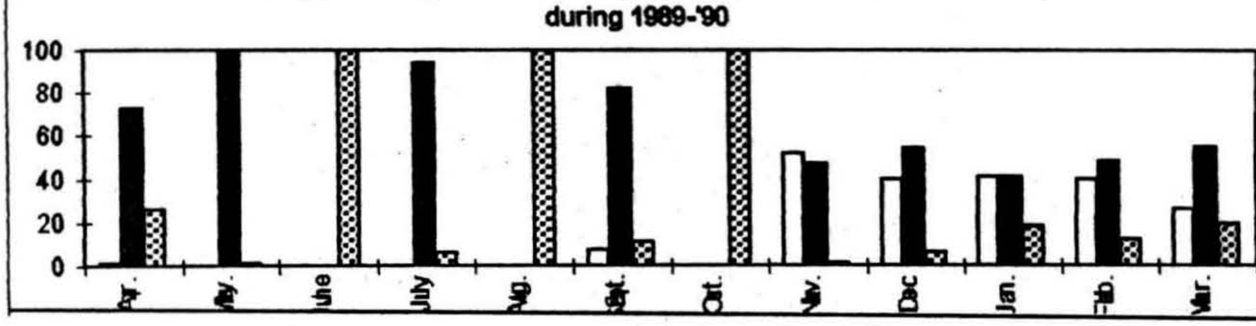


PLATE 36.

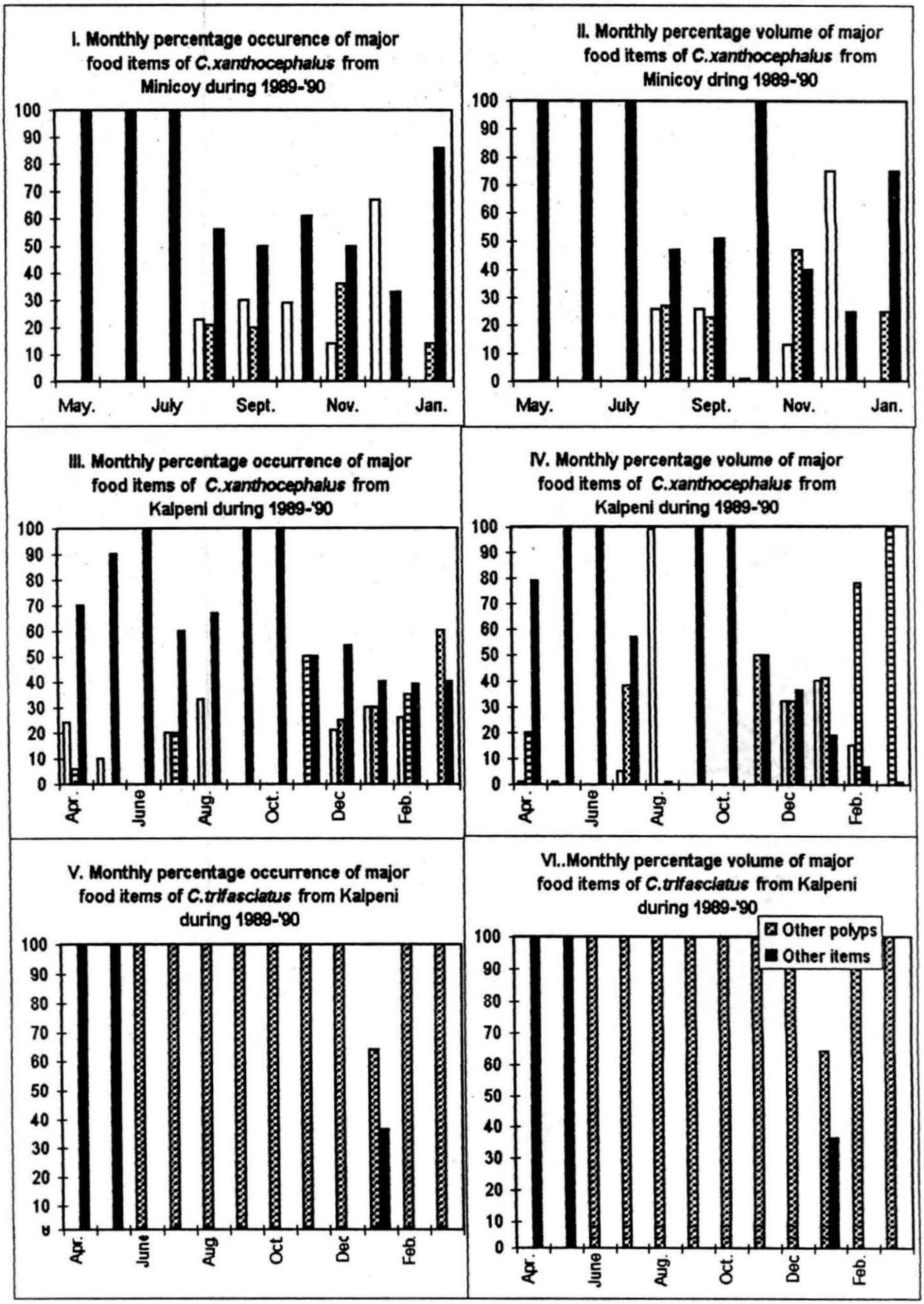
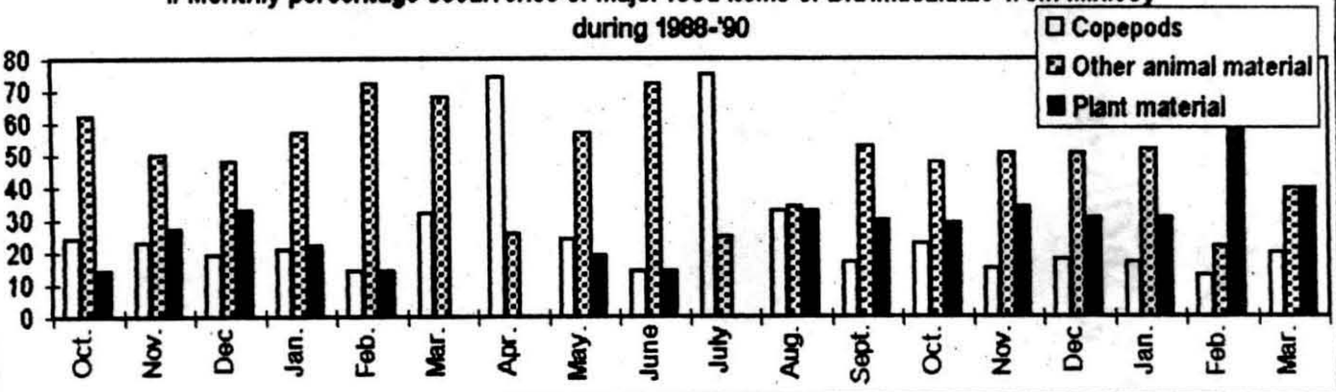
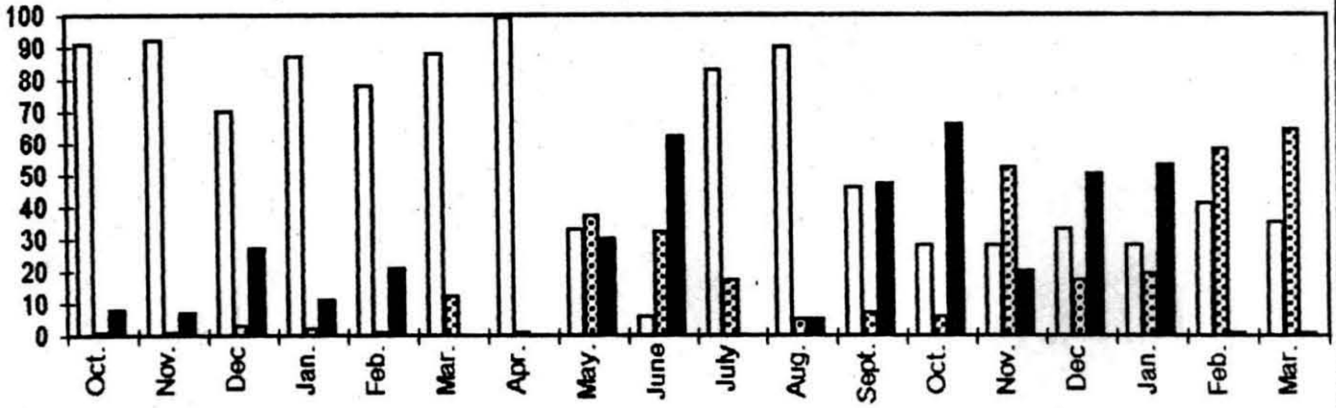

I. Monthly percentage occurence of major food items of C.xanthocephalus from Minicoy during 1989-'90
0 10 20 30 40 50 60 70 80 90 100
May. July Sept. Nov. Jan.
II. Monthly percentage volume of major food items of C.xanthocephalus from Minicoy dring 1989-'90
0 10 20 30 40 50 60 70 80 90 100
May. July Sept. Nov. Jan.
III. Monthly percentage occurrence of major food items of C.xanthocephalus from Kalpeni during 1989-'90
0 10 20 30 40 50 60 70 80 90 100
Apr. June Aug. Oct. Dec Feb.
IV. Monthly percentage volume of major food items of C.xanthocephalus from Kalpeni during 1989-'90
0 10 20 30 40 50 60 70 80 90 100
Apr. June Aug. Oct. Dec Feb.
V. Monthly percentage occurrence of major food items of C.trifasciatus from Kalpeni during 1989-'90
0 10 20 30 40 50 60 70 80 90 100
Apr. June Aug. Oct. Dec Feb.
VI..Monthly percentage volume of major food items of C.trifasciatus from Kalpeni during 1989-'90
Other polyps
Other items
0 10 20 30 40 50 60 70 80 90 100
Apr. June Aug. Oct. Dec Feb.

PLATE 37.

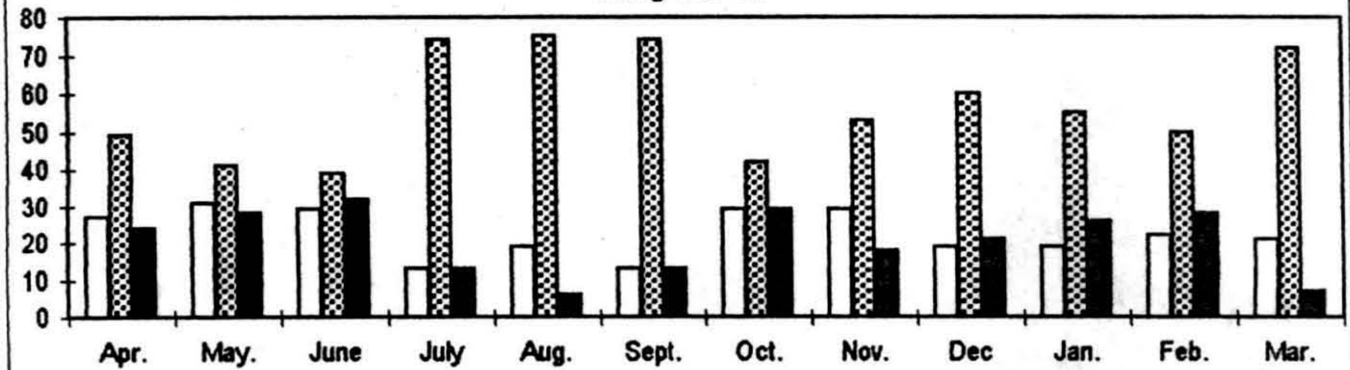
I. Monthly percentage occurrence of major food items of *D.trimaculatus* from Minicoy during 1988-'90



II. Monthly percentage volume of major food items of *D.trimaculatus* from Minicoy during 1988-'90



III. Monthly percentage occurrence of major food items of *D.trimaculatus* from Kalpeni during 1989-'90



IV. Monthly percentage volume of major food items of *D.trimaculatus* from Kalpeni duirng 1989-'90

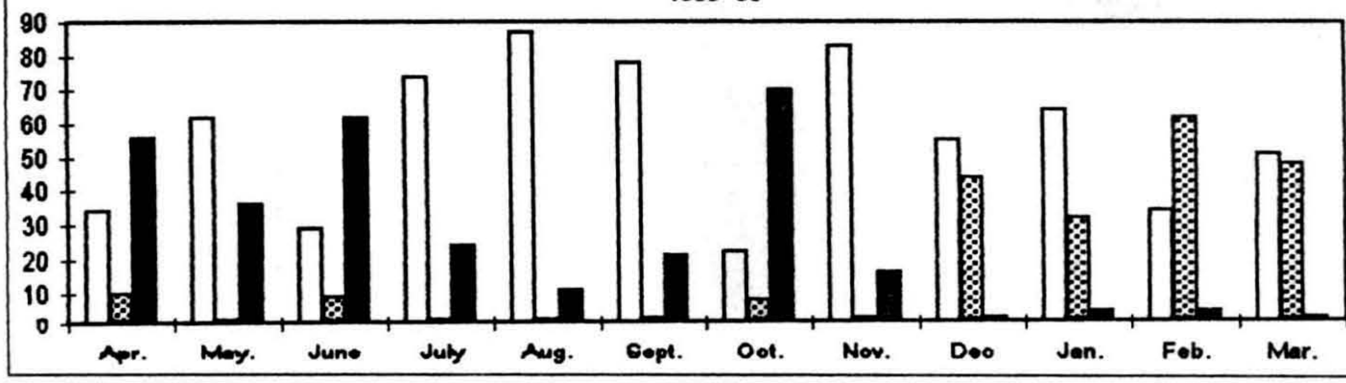
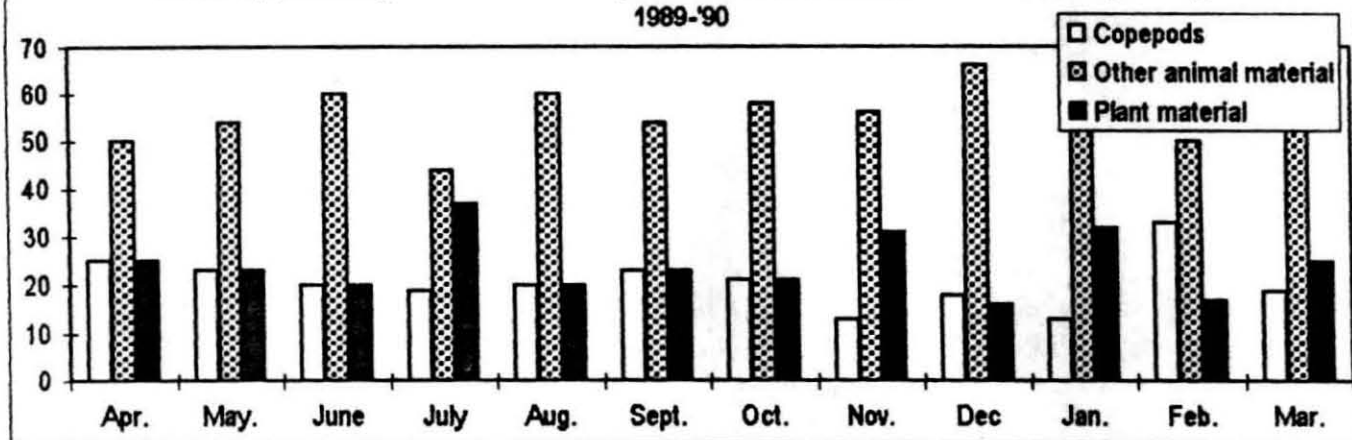
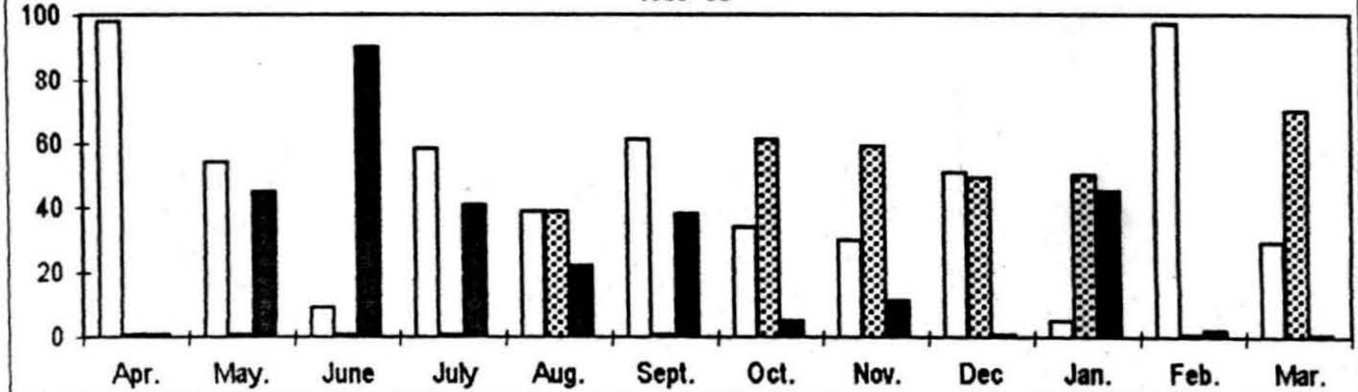


PLATE 38.

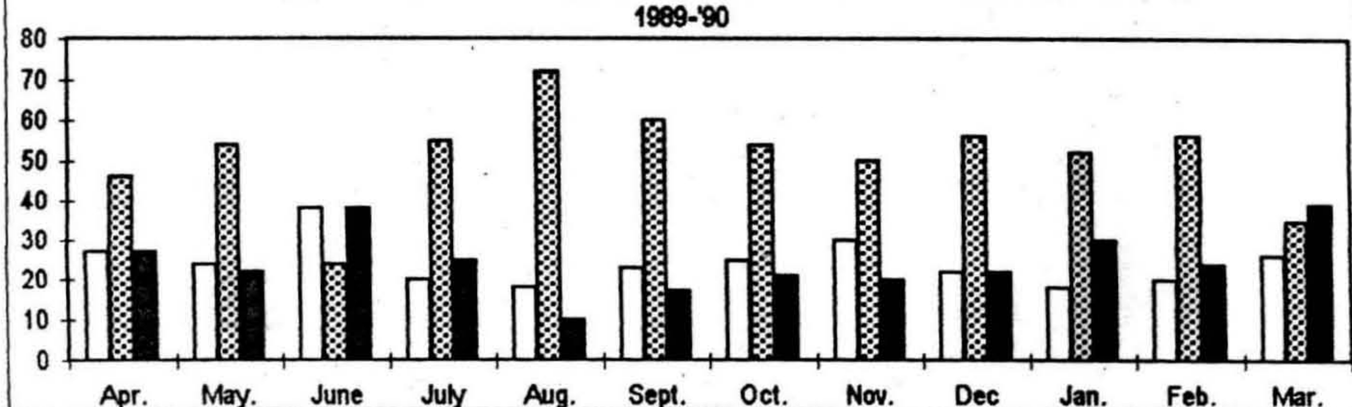
I. Monthly percentage occurrence of major food items of *D.reticulatus* from Minicoy during 1989-'90



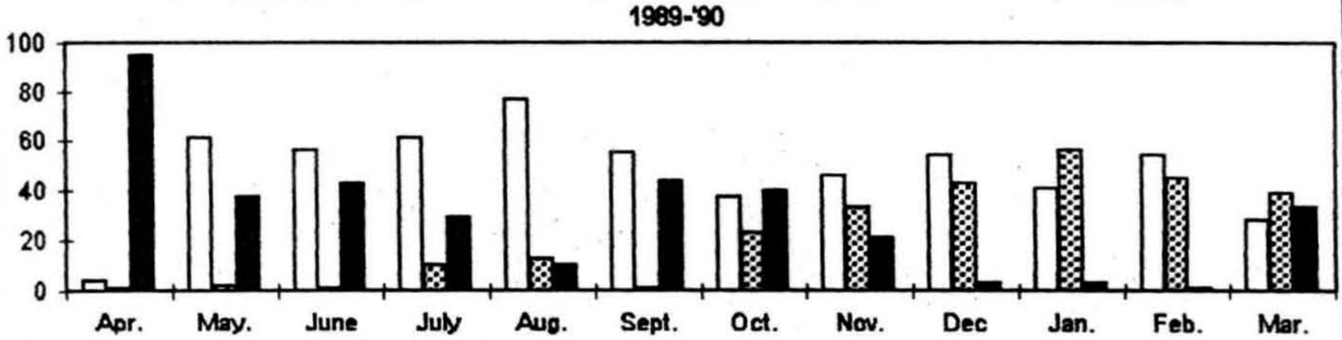
II. Monthly percentage volume of major food items of *D.reticulatus* from Minicoy during 1989-'90



III. Monthly percentage volume of major food items of *D.reticulatus* from Kalpeni during 1989-'90



IV. Monthly percentage volume of major food items of *D.reticulatus* from Kalpeni during 1989-'90



CHAPTER V

REPRODUCTIVE BIOLOGY

Pl. 39-62

5.1. INTRODUCTION

Sexual maturation and spawning are important aspects of life history of coral reef fishes, yet our understanding of the reproductive biology of chaetodontids is remarkably limited (reviewed by Thresher 1984, Walsh 1987). The majority of studies on reproductive activity have employed gonadosomatic indices (Ralston 1981, Tricas and Hiramoto 1989 and Gharaibeh and Hulings 1990), macroscopic classification of gonad ripeness (Munro *et al.* 1973, Nzioka 1979), or direct observations of spawning (Neudecker and Lobel 1982, Robertson 1983, Lobel 1989). Studies exclusively devoted to sex change (Moyer and Nakazono 1978, Ross 1984) and the histological analysis of gamete development (Bouain and Siau 1983 and Hourigan and Kelley 1985, Tricas and Hiramoto 1989) are the other works. Detailed reproductive data exist for only one species, *Chaetodon miliaris*, studied by Ralston (1976b, 1981) and no published analysis of sexual differentiation, gonad maturation or oocyte development are available for any of the chaetodons. Some data on the reproductive aspects of chaetodons are given by Vijay Anand (1994).

In the case of pomacentrids, maturation and ova diameter studies on *Chromis caeruleus* is made by Madan Mohan *et al.* (1986b), and that of *D.aruanus* by Pillai *et al.* (1985a). Ova measurements of *C.caeruleus* is reported by Swerdloff (1970) and that of *D.trimaculatus* by Breder and Rosen(1966) and Vijay Anand (1994). The different maturation studies on the ovary of *D.reticulatus* has been done by Schwarz and Smith (1990).

In the present study, two families, Chaetodontidae (*Chaetodon auriga*, *C.lunula*, *C.xanthocephalus* and *C.trifasciatus*) and Pomacentridae (*Dascyllus trimaculatus* and *D.reticulatus*) have been selected to study the various aspects of reporductive biology, namely sex ratio, maturity stages,spawning season and fecundity.

5.2. MATERIALS AND METHODS

Since there appeared no external characters to distinguish the sexes of the chaetodons and pomacentrids, the fishes were cut opened and the gonads were examined under the microscope to determine the sex of fishes. For the pomacentrid fishes, a chi-square test of null hypothesis was applied to find out any significant difference between the hypothetical and observed sex ratios.

The different maturity stages of the gonads were determined based on their morphological and microscopical examinations. The testes were classified into six and ovaries into nine stages. This classification of the gonads was done mainly based on Kesteven's (1960) classification, but with necessary modifications. The different maturity stages of the testis are:- Stage I -immature, Stage II - maturing, Stage III - mature, Stage - IV - ripe, Stage - V - Spawning and Stage - VI - spent. The different stages of maturity of the ovary are :- Stage I was sub - divided into stage Ia and stage - Ib. Stage Ia - immature virgins, Stage Ib - maturing virgins and maturing females after previous spawning. Stage II - Ova with irregular shape. Stage III - in chaetodons ova assumed spherical shape and that of the pomacentrids started elongating slightly. Stage IV - ovary yellowish with prominent blood vessels. Stage V - ovary golden yellow in colour. Blood vessels more prominent. The pomacentrid eggs started development of stalk which is a characteristic feature of damersal eggs. Stage VI - fully spherical eggs in chaetodons and elongated in pomacentrids. Spent - Ovary blood shot and placcid. Atresia - ovary with distintegrating eggs.

Size at first maturity was determined by linear regression of size on percentage maturity. Except for *C.auriga*, the size at first maturity of the other chaetodons was not done considering the inadequate number of fishes in various size groups. The difficulty in collecting these fishes from the lagoon is also mentioned by Vijay Anand(1994).

The gonado-somatic index was calculated using the formula,

$$GSI = \frac{\text{Gonad weight in gms}}{\text{Fish weight in gms}} \times 100$$

For estimating fecundity, ovaries at and above stage - IV maturity were used. For this the weight of the ovary was taken and was cut into more or less equal sized sub - samples. Weight of three sub - samples was taken individually and the total number of eggs in each sub-sample was counted under a dissection microscope. The average number of eggs in the sub samples was used for calculating fecundity (Bagenal and Braum, 1971). The ova diameter was measured in micrometer divisions, where, one micrometer division = 0.015 mm.

The correlation between fecundity and total length of fish, between fecundity and total weight of fish and that between fecundity and ovary weight were also determined.

5.3. RESULTS

5.3.1 SEX RATIO

It was observed that in the wild the chaetodons occur in pairs. *C.auriga* was observed to start pair formation on reaching 9 cms TL, and fishes above 9 cms Tl were always found in pairs. The chaetodons were never found in groups. Hence their sex ratio was expected to be 1:1. Since the composition of monthly samples collected from the wild was dependent on the chances of escape of either member of the pair while fishing, the sex ratio and the chi-square test was not done for the chaetodons in the present study. As the chaetodons were observed in pairs, the present study considers the male to female ratio of chaetodons in the natural population as 1:1.

The two pomacentrids were observed to be strongly site - attached and colonial fishes in which almost all size groups were represented in any given colony populising any individual coral. It was also observed that in any such colony, the biggest fishes were always males and the females outnumbered the males. The composition of the colony of *D.trimaculatus* and *D.reticulatus* from Minicoy and Kalpeni is given in Tables 5.1 - 5.4. These tables show the percentage of males, females and indeterminates, but the sex ratio of these two fishes was calculated excluding the precentage of the indeterminates. The chi-square values showed significant deviation from the expected 1:1 ratio, except for March, June and September '89 in *D.trimaculatus* from Minicoy and for September and November 1989 in the Kalpeni samples. For *D.reticulatus* the 1:1 ratio was observed only during October in the Kalpeni samples.

5.3.2. MATURITY

5.3.2.1. SIZE AT SEXUAL DIFFERENTIATION

Plate 39 gives the precentage occurence of males, females and indeterminates in various size groups of the chaetodons. The class interval was taken as 1 cm. It was observed that the sexual differentiation in *C.auriga* occurred at the size between 6 - 6.9 cm in the Minicoy samples. In Kalpeni samples they differentiated at the size groups 5 - 5.9 cms, but indeterminates also were observed in the 9 - 9.9 cms size groups both in Minicoy and Kalpeni samples. Sexual differentiation in *C.lunula* was found to be taking place among the 8 - 8.9 cm size groups in Minicoy and between 6 - 6.9 cms in Kalpeni. Female *C.xanthocephalus* were observed in the 5 - 5.9 cms size groups in the Kalpeni samples and males in the 8 - 8.9 cms class in Minicoy. Male and female *C.trifasciatus* were observed in the 5 - 5.9 cms size class. The morphological differences at different sizes of the chaetodons are shown in plate 40.

TABLE 5.1. SEX RATIO OF *D.TRIMACULATUS* IN MINICOY SAMPLES DURING 1988 - '90

Months	Total No. of Fish	Males %	Females %	Indeterminates %	Sex Ratio	Chi-square
October	23	13.04	34.78	52.17	1:2.67	20.66
November	23	34.78	65.22		1:1.88	9.26
December	12	16.67	83.33		1:5	44.44
January	20	25	75		1:3	25
February	20	10	40	50	1:4	36
March	18	33.33	33.33	33.33	1:1	0
April	20	25	50	25	1:2	11.12
May	28	7.14	57.14	35.72	1:8	60.5
June	28	50	50		1:1	0
July	20	15	45	40	1:3	25
August	10	20	80		1:4	36
September	24	12.5	62.5	25	1:5	44.44
October	34	5.88	23.53	70.59	1:4	36
November	36	11.11	11.11	77.78	1:1	0
December	32	25	56.25	18.75	1:2.25	14.79
January	32	15.63	40.62	43.75	1:2.6	19.75
February	20	25	75		1:3	25
March	10	20	80		1:4	36

$X^2 = 3.84$

TABLE 5.2. SEX RATIO OF *D.TRIMACULATUS* IN KALPENI SAMPLES DURING THE YEAR 1989 - 1990

Months	Total No. of Fish	Males %	Females %	Indeterminates %	Sex Ratio	Chi-square
April	39	30.77	61.54	7.69	1:2	11.11
May	36	8.33	66.67	25	1:8	60.49
June	20	20	60	20	1:3	25
July	20	30	70		1:2.3	16
August	28	14.29	71.42	14.29	1:5	44.44
September	20	50	50		1:1	0
October	24	12.5	37.5	50	1:3	25
November	20	50	50		1:1	0
December	32	3.13	81.25	15.62	1:26	85.73
January	36	5.56	83.33	11.11	1:15	76.56
February	31	6.45	70.97	22.58	1:11	69.44
March	21	9.52	76.19	14.29	1:8	60.49

$X^2 = 3.84$

TABLE 5.3. SEX RATIO OF *D.RETICULATUS* IN MINICOY SAMPLES DURING THE YEAR 1989 - 1990

Months	Total No. of Fish	Males %	Females %	Indeterminates %	Sex Ratio	Chi-square
April	20	5	50	45	1:9	66.94
May	20	10	65	25	1:6.5	53.77
June	20	10	90		1:9	64
July	40	12.5	62.5	25	1:5	44.44
August	40	2.5	77.5	20	1:31	87.89
September	21	4.76	23.81	71.43	1:5	44.44
October	54	7.41	42.59	50	1:5.75	49.52
November	57	3.51	71.93	24.56	1:20.5	82.26
December	42	4.76	90.48	4.76	1:19	81
January	31	19.35	80.65		1:4.17	37.57
February	20	15	85		1:5.67	49
March	20	10	90		1:9	64

$X^2 = 3.84$

TABLE 5.4. SEX RATIO OF *D.RETICULATUS* IN KALPENI SAMPLES DURING THE YEAR 1989 - 1990

Months	Total No. of Fish	Males %	Females %	Indeterminates %	Sex Ratio	Chi-square
April	49	26.53	65.31	8.16	1:2.46	17.83
May	30	13.33	73.33	13.33	1:5.5	47.93
June	38	31.58	63.16	5.26	1:2	11.11
July	24	25	75		1:3	25
August	28	21.43	78.57		1:3.67	32.65
September	21	28.57	71.43		1:2.5	18.37
October	21	14.29	14.29	71.42	1:1	0
November	22	9.1	45.45	45.45	1:5	44.44
December	31	19.35	80.65		1:4.17	37.57
January	40	20	80		1:4	36
February	31	22.58	67.74	9.68	1:3	25
March	24	33.33	66.67		1:2	11.11

$X^2 = 3.84$

Plate 41 gives the percentage of indeterminates, males and females of *D.trimaculatus* and *D.reticulatus* from Minicoy and Kalpeni. Differentiation of males and females occurred in the size class of 3 - 3.9cms in *D.trimaculatus* in Minicoy and in Kalpeni females differentiated between 3 - 3.9cms and males between 4 - 4.9cms. In *D.reticulatus* females differentiated between 2 - 2.9cms and males between 3 - 3.9cms in both samples. The figures showed that majority of males were present in the larger size groups. The morphological variations among different size groups of the pomacentrids are shown in the plate 42.

5.3.2.2. SIZE AT FIRST MATURITY

Plate 43 shows the percentage occurrence of different maturity stages in the various size groups of *C.auriga*. Among the male *C.auriga* form Minicoy, the more advanced stages of maturity were observed in size class of 9 - 9.9cms and mature females in the 11 - 11.9cms size class. In Kalpeni advanced stages of maturity were observed in 7 - 7.9cms size groups of males and spent females in the same size class of 11 - 11.9cms.

The size at first maturity at 50% level of *C.auriga* was calculated as 13.26cms by the linear relationship betweeen size at first maturity and size class, $SM = -223.2 + 20.6\ SG$, where the correlation coefficient $r = 0.917$. On the graph the value observed was 13.1 cms as shown in plate 44.

Plate 45 shows the distribution of mature males and females at different maturity stages in the pomacentrids in various size groups. More mature females were distributed between 3 and 8.9 cms in *D.trimaculatus* and males between 6 and 10.9 cms. In *D.reticulatus* females were found distributed between 2 and 6 cms and males between 3 and 7.9 cms. The size at first maturity of the pomacentrids is given in plate 44. The size at first maturity of *D.trimaculatus* in Minicoy samples at 50% level was calculated as 6.72 cms and the linear relationship is given by: SM = 21.97 + 4.17 SG, where r = 0.46. On the graph the size of maturity was found to be 4.3 cms. In the Kalpeni samples, the size at first maturity at 50% level was 6.74 cms, in which the linear relationship was calculated as SM = -94.92 + 21.5 SG, where r = 0.99. In *D.reticulatus* from Minicoy, size at first maturity at 50% level was 4.29 cms and the linear relationship was SM = -19.95 + 16.3 SG, where r = 0.99. The value obtained on the graph was 4.4cms. In the Kalpeni samples, the size at first maturity at 50% level was 3.6 cms and on the graph it was 3.8cms. The linear relationship is given by: SM = 24.5 + 7.6 SG , where r = 0.65.

5.3.3. SPAWNING SEASON

The monthly percentage occurrence of different maturity stages of *C.auriga*, *C.lunula* and *C.xanthocephalus* are given in plate 45 and 46. In *C.auriga* from Minicoy, the most advanced stages of maturity (stage VI) in females were observed in August, stage V during May, June, October and January and stage IV during May. Spent ovaries were observed during May, August and October. In male *C.auriga*, stage V testes were oberved during June, August, September and October. In Kalpeni, spent ovaries were found during October. Advanced maturity stages were not found in the females of *C.lunula* both in Minicoy and Kalpeni samples. Same observation was made for *C.xanthocephalus* from Kalpeni. Only stage Ib female *C.xanthocephalus* from Minicoy and *C.trifasciatus* were represented in the samples collected. An important observation made was the year - round occurrence of stage Ib females in the four *Chaetodon* species in both stations.

Plate 48 - 50 give the percentage of GSI at different stages of maturity in male and female *C.auriga* from Minicoy and Kalpeni. A narrow range of 0.01 - 0.11 was observed for male *C.auriga* from Minicoy and 0.01 - 0.16 for the samples from Kalpeni. In Minicoy the GSI of immature virgins ranged between 0.003 and 0.07, and GSI at Ib and II between 0.04 and 0.90, IV between 1.4 and 3, V between 1.3 and 7, VI between 1.2 and 6.8 and spent between 0.51 and 0.83. In Kalpeni the GSI of Ia maturity stage ranged between 0.01 and 0.08, that of Ib between 0.01 and 1.02, II between 0.06 and 1.67, III betwen 0.01 and 1.24 and spent between 0.38 and 0.65. It was observed that the GSI values for Ib alone ranged between 0.05 and 0.9 in Minicoy and between 0.01 and 1.7 in Kalpeni. The stage Ib included the maturing virgins and also the maturing females after previous spawning and this difference between the maturing virgins and maturing females after previous spawning could readily be distinguished by the distribution of GSI values at this stage. The lower GSI values were that of the

maturing virgins and the high values were that of the previously spawned females. At the advanced stages of maturity (stage IV, V and VI), the GSI values ranged between 1 and 7. In *C.lunula* (plate 51) the GSI was observed to be similiar to that of *C.auriga*. However, advanced stages of maturity were not represented in the samples collected. Almost the same pattern of GSI values were observed in *C.xanthocephalus* and *C.trifasciatus* (plate 51)

Monthwise percentage of GSI of *C.auriga* is given in plate 52. Highest GSI was observed during August, September and October for females in Minicoy and that for males during July. In Kalpeni highest GSI for male *C.auriga* was observed in May and that for females during July. In male *C.lunula* during April, November and February the highest GSI values were observed and for females during May, November, December and February (plate 53) in the Kalpeni samples. In Minicoy the highest values for males were observed during June, September, October, December, March and April and for females during July, September, November, December and January (Plate 53). High GSI values for male *C.Xanthocephalus* were observed during September, October, December and February and in females it was during August and December in Kalpeni as given in plate 53. In Kalpeni for male *C.xanthocephalus* high GSI values were oberved in April, July and March and for females during June and March (Plate 53). For *C.trifasciatus* males showed high GSI values during May and September and females in October (Plate 53).

Plate 54 and 55 show the monthly percentage occurence of different maturity stages in *D.trimaculatus* and

D.reticulatus from Minicoy and Kalpeni. In male *D.trimaculatus* from Minicoy the advanced stages of maturity were observed year - round except during March, April and November and in Kalpeni except during May, June, July and August. In female *D.trimaculatus* advanced stages were not observed during December, February, March , July, August, October and November. But it was observed that fishes at stage Ib maturity were found occuring year - round with very few exceptions. In the Kalpeni samples females with advanced ovaries were observed year - round except during August, December and March. Females with Ib stage ovaries were also observed year - round except during September, October and November. In male *D.reticulatus* advanced maturity stages were observed every month in Minicoy and Kalpeni, but except during October. Females at advanced maturity stages were not observed during October and March in Kalpeni and females at Ib maturity stages were found occurring in eight months.

The percentage occurrence of GSI at different stages of maturity in *D.trimaculatus* and *D.reticulatus* are given in plates 56 to 58. The GSI values at different maturity stages in male *D.trimaculatus* from both the stations were observed to be distributed between 0.02 and 0.6. In the females, GSI at stage Ia maturity ranged between 0.04 and 0.3, that at Ib between 0.04 and 0.9, II between 0.1 and 0.5, III between 0.1 and 1.6, IV between 0.1 and 2.1 and V and VI between 2 and 6 in both stations. GSI of the spent females ranged between 1 and 2. In male *D.reticulatus*, irregular distribution of GSI values at different maturity stages was observed in both the stations. In Minicoy GSI at stage II ranged between 0.01 and 0.4, IV between 0.2 and 0.5, stage V between 1 and 6 and VI between 0.4 and 0.6. In Kalpeni GSI at stage I and II ranged between 0.01 and 0.3, III between 0.1 and 0.3, IV between 0.1 and 2, V between 0.2 and 1.6 and VI between 0.2 and 0.5. This irregularity in the GSI values was observed in the females also. In females GSI at Ia maturity ranged between 0.1 and 0.4, Ib between 0.1 and 0.6, II between 0.2 and 0.7, III between 0.1 and 2, IV between 0.1 and 6.5 and V between 0.3 and 12 in the two samples.GSI of the spent females was observed between 0.7 and 2 in the Minicoy samples and between 0.1 and 0.4 in the Kalpeni samples. The GSI values of females with disintergrating ovaries was found between 0.4 and 0.6 in the Kalpeni samples.

Plate 59 shows the monthly GSI of the two pomacentrid fishes in the Minicoy and Kalpeni. In the Minicoy samples, very little variation was observed in the monthly GSI of the male *D.trimaculatus*. In the females also the observation was almost same, with the exception of a relatively high GSI value during December, 1989. In the Kalpeni samples also more or less same observations were made for the males, whereas in females two peaks were observed in June and October. In *D.recticulatus,* males showed a peak in the GSI values during January in Minicoy and September in Kalpeni. The females showed a peak during January and March in Minicoy and during May, June, July, August, September and December in Kalpeni.

5.3.4. FECUNDITY

Table 5.5 gives the fecundity in the various size groups of *C.auriga*. The number of eggs ranged between 16885 and 87494. Variations could be observed in the number of eggs produced at different sizes. The highest number of eggs was observed in a fish of 14.3 cms TL and the lowest in a 12.6 cms fish.

In *C.auriga* the ova diameter ranged between 0.015 mm and 0.09 mm at stage Ib, between 0.03 and 0.15 mm at stage II, between 0.18 and 0.24 at stage III, between 0.225 and 0.33 mm at stage IV, between 0.24 and 0.42 mm at stage V and 0.345 and 0.42 mm at stage VI as given in plate 60.

The number of eggs in *D.trimaculatus* ranged between 8700 and 18050 in Minicoy and between 1428 and 8470 in Kalpeni. The highest number of eggs was observed in a fish of 7.9 cms TL in Minicoy and in Kalpeni in a fish of 6.2 cms TL. In *D.reticulatus* from Minicoy fecundity ranged between 3926 and 17272 as observed in fishes of 4.28 cms TL and 6 cms TL respectively. In Kalpeni fecundity was observed between 331 in a fish of 3.8 cms TL and 18346 in a fish of 5.5 cms TL (Table 5.6 - 5.9).

In *D.trimaculatus* in both samples, ova diameter ranged between 0.015 and 0.105 mm at stage Ib, between 0.03 and 0.195 mm at stage II, between 0.105 and 0.285 mm at stage III. The width of ova at stage IV ranged between 0.165 and 0.345 mm and length between 0.195 and 0.39 mm. At stage V width between 0.295 and 0.39 mm and lenght between 0.36

TABLE 5.5. NUMBER OF EGGS IN *C.AURIGA* AT DIFFERENT SIZES

Total length of fish in cms	Weight of fish in gms	Weight of ovary in gms	Fecundity
12.6	49.5	0.6	16885
13.4	61.173	1.481	43245
14	67.54	3.37	46662
14	71.425	0.918	29055
14.3	83.25	1.94	87494
14.5	81.67	5.704	79856
14.6	84.373	1.56	42284

TABLE 5.6. NUMBER OF EGGS IN *D.TRIMACULATUS* AT DIFFERENT SIZES FROM MINICOY

Total length of fish in cms	Weight of fish in gms	Weight of ovary in gms	Fecundity
8.6	19.161	1.213	17820
8.3	13.883	0.145	8700
7.9	16.62	0.172	12801
7.9	15.662	0.554	18048
7.5	13.327	0.886	16801

TABLE 5.7. NUMBER OF EGGS IN *D.TRIMACULATUS* AT DIFFERENT SIZES FROM KALPENI

Total length of fish in cms	Weight of fish in gms	Weight of ovary in gms	Fecundity
7.7	12.88	0.067	3112
6.9	9.22	0.168	7728
6.5	7.47	0.055	1428
6.4	6.933	0.155	6198
6.3	6.072	0.134	5346
6.2	6.803	0.181	8470
5.7	5.023	0.034	1108
5.7	5.925	0.185	8453

TABLE 5.8. NUMBER OF EGGS IN *D.RETICULATUS* AT DIFFERENT SIZES FROM MINICOY

Total length of fish in cms	Weight of fish in gms	Weight of ovary in gms	Fecundity
6	6.126	0.729	17272
5.9	6.034	0.475	10640
5.4	4.574	0.384	8558
5.4	4.092	0.391	9650
5.1	3.478	0.257	5397
5.1	3.992	0.338	6950
4.8	3.19	0.24	5273
4.8	2.912	0.216	3926
4.2	2.204	0.143	5347

TABLE 5.9. NUMBER OF EGGS IN *D.RETICULATUS* AT DIFFERENT SIZES FROM KALPENI

Total length of fish in cms	Weight of fish in gms	Weight of ovary in gms	Fecundity
6.3	7.052	0.565	17332
6	5.774	0.474	10707
5.8	5.44	0.423	7806
5.7	4.969	0.308	9076
5.7	5.891	0.275	6072
5.6	4.667	0.43	10908
5.5	5.173	0.547	18346
5.5	4.584	0.138	10271
5.4	4.215	0.264	8905
5.3	4.221	0.229	7042
5.3	3.952	0.194	4092
5.1	3.546	0.16	4226
5	3.333	0.183	15504
5	3.474	0.6	8610
5	3.301	0.284	7927
5	3.312	0.256	7565
5	3.158	0.119	3392
4.7	2.625	0.1	2792
4.6	2.66	0.125	4179
4.5	2.428	0.106	2847
4.5	2.645	0.143	4796
4.2	2.11	0.06	1989
3.8	1.255	0.011	331

and 0.48 mm and at stage VI, width of ova ranged between 0.405 and 0.42 mm and length between 0.495 and 0.525 mm. (Plate 61 and 62).In *D.reticulatus* from both the samples ova diameter ranged between 0.015 mm and 0.105 mm at stage I, between 0.03 and 0.195 mm at stage II, between 0.12 and 0.27 mm at stage III, at stage IV between 0.12 and 0.36 mm and at stage V between 0.18 and 0.45 mm. The length of ova ranged between 0.15 and 0.42 mm at stage IV and stage V between 0.21 and 0.6 mm.

The relatioship of fecundity with total length of body, total weight of body and ovary weight in the fishes studied are as follows.

Fecundity and total length relationship

C.AURIGA :- There showed no significant relationship between fecundity and the total length of the fish.
The fecundity - total length relationship in *C.auriga* is estimated as:
log F = -8.9665 + 7.34 log L where, the correlation coefficient r = 0.376 and critical coefficient r^2 = 0.141.

D.TRIMACULATUS (Minicoy) :- Significant correlation was observed.
log F = 8.997 + 0.373 log L where, r = 0.675 and r^2 = 0.455.

D.TRIMACULATUS (Kalpeni):- No significant correlation was observed.
log F = 7.764 + 0.307 log L where, r = 0.037 and r^2 = 0.001

D.RETICULATUS (Minicoy) :- Significant correlation was observed.

$\log F = -4.66 + 3.44 \log L$ where, $r = 0.833$ and $r^2 = 0.695$

D.RETICULATUS (Kalpeni) :- Significant correlation was observed.

$\log F = -14.525 + 5.901 \log L$ where, $r = 0.821$ and $r^2 = 0.675$

Fecundity - total weight relationship

C.AURIGA :- Significant relation was observed between fecundity and total weight of fish.

$\log F = 0.868 + 2.308 \log W$ where, $r = 0.796$ and $r^2 = 0.634$.

D.TRIMACULATUS (Minicoy) :- Correlation was significant.

$\log F = 9.35 + 0.153 \log W$ where, $r = 0.727$ and $r^2 = 0.529$

D.TRIMACULATUS (Kalpeni) :- Correlation was not significant

$\log F = 7.723 + 0.309 \log W$ where, $r = 0.112$ and $r^2 = 0.012$.

D.RETICULATUS (Minicoy) :- Significant correlation was observed.

$\log F = 7.3019 + 1.183 \log W$ where, $r = 0.863$ and $r^2 = 0.746$

D.RETICULATUS (Kalpeni):- Correlation was significant.

$\log F = 6.269 + 1.862 \log W$ where, $r = 0.842$ and $r^2 = 0.710$

Fecundity - ovary weight relationship

C.AURIGA :- significant correlation was found.

$\log F = 10.340 + 0.615 \log OW$ where, $r = 0.822$ and $r^2 = 0.676$

D.TRIMACULATUS (Minicoy) :- Significant correlation was observed.

log F = 9.596 + 0.899 log OW where, r = 0.997 and r^2 = 0.993

D.TRIMACULATUS (Kalpeni) :- Correlation was found to be significant.

log F = 10.979 + 1.176 log OW where, r = 0.973 and r^2 = 0.947

D.RETICULATUS (Minicoy) :- Significant correlation was observed.

log F = 9.877 + 0.851 log OW where, r = 0.901 and r^2 = 0.811

D.RETICULATUS (Kalpeni) :- Significant correlation was observed.

log F = 10.090 + 0.826 log OW where, r = 0.855 and r^2 = 0.73

5.4. DISCUSSION

A long - term pair bond is believed to exist in most of the *Chaetodon* species and the general pattern is that most individuals of many species are found in heterosexual pairs(Reese, 1975, 1981, Neudecker and Lobel 1982). Reese (1981) estimated the strength of the pair bond by establishing 95% confidence limits for the occurrence of individuals of a given species in the paired social condition as opposed to being solitary or being in a group of 3 or more individuals. Lobel (1989) reported the sex ratio of mature *C.multicinctus* collected in pairs as 1:1. However Aiken(1983) found sex ratio of the various species of chaetodons caught in traps, in which the females outnumbered the males. He also observed variation in sex ratio of *C.capistratus* caught in traps from two different stations due to difference in depth. Vijay Anand (1994) reported sex ratio of *C.collare* as 1:0.49, that of *C.melannotus* as 1:1.64 and that of *C.trifasciatus* as 1:0.67, where the fishes were collected using encircling and drive-in-nets. This difference in the behavioural ecology of these fishes agrees with the observation made in the present study that as the fishes were seen in pairs in the wild, unless both members of the pair are caught while sampling, the sex ratio of the population will not be in the 1:1 ratio.

Schwarz (1980) reported that almost all *D.reticulatus* are females. *Dascyllus marginatus* are reported to be monomorphic fish, organized in stable territorial groups with a slightly large male dominating all females (Fricke, 1980). Schwarz (1995) observed social groups of *D.reticulatus* contained 1 - 2 resident males and several females, all of which were smaller than the smallest resident male. Fricke (1980) also reported sex ratio in the prėvalent groups of this fish as female biased. In the Gulf of Akaba, Sinai Peninsula, Holzberg (1973) observed polygynous groups of *D.marginatus* consisting on the average of 1 male and 3.3 females as quoted by Fricke (1980). Solitary, monogamous or haremic or multi-male group with promiscuous mating has been reported in *D.aruanus* (Fricke, 1980). Promiscuous mating is also reported in the pomacentrid, *Stegastes nigricans* by Karino and Nakazono (1993). Thresher and Moyer (1983) reported sex ratios significantly different from unity in the pomacentrid fishes *Glyphidodontops rollandi* and *G.cyaneus*. Schwarz and Smith

(1990) reported one female *D.reticulatus* spawned with several males. Polygamous mating in the pomacentrids, *Pomacentrus flavicauda* and *P.wardi* are reported by Doherty (1983). A correlation between the coral size and group size and sex ratio of *D.marginatus* was observed by Fricke (1980). Ross(1990) observed a relationship between sex ratio and sex change in pomacentrids. He referred sex - ratio induction to sex change caused by a change in the sex ratio of a social group through recruitment or mortality. According to him, normally the largest single initial - sex individual changes sex, returning the group sex ratio to a sub-threshold value. In size - ratio induction the relative size ratio of a group rather than the group sex ratio is a cue for sex change. When a threshold ratio of the number of fish smaller than the sex - change candidate to the number of fishes larger than the sex- change candidate in a social group is exceeded, a fish changes sex. The phenomena discussed above explain the occurence of the greater percentage of females obtained in the present study. However Madan mohan *et al.* (1986b) reported a 1:1.44 ratio for the pomacentrid fish *Chromis caeruleus* and 1:1.61 for *D.aruanaus* by Pillai *et al.* (1985a) and Vijay Anand (1994) reported the sex ratio of *D.trimaculatus* as 1:0.49.

According to Reese (1981) the chaetodons are seggregating into pairs according to size. He reported that the members of the pair are all sexually mature adults and they do not differ greatly in size. Pair formation was found to occur among fishes of sizes 9 cm TL and above during the present study. Tricas and Hiramoto (1989) reported smaller fishes of *C.multicinctus* below 6.2 cms lacked differentiated gonads. He also observed the same fish as small as 5 cms SL with structurally differentiated ovaries often form pairs. The onset of reproductive maturity in both males and females of *C.miliaris* is known to occur at the SL of 9 cms (Ralston 1976b). The breeding females of *C.miliaris* were defined as those greater than 10 cms SL by Ralston (1981). Fully mature *C.collare* of 101 mm, *C.octofasciatus* 71 - 80 mm, *C.trifasciatus* 81 - 90 , male *C.melannotus* of 71 - 80 and female 81 - 90 mm were reported by Vijay Anand (1994). In the present study also mature males were observed among size groups between 9 and 9.9 cms TL and mature females among 11 - 11.9 cms TL. Spawning females of *C.miliaris* of 11.7 cms SL were observed by Ralston(1981). Aiken (1983) reported the size of the smallest mature male of *C.capistratus* as 8.8 cm TL and that of the female as 9.2 cms TL; in male *C.striatus* it was 13.2 cms and in females 12.4 cms TL and 13.4 cms TL in male *C.ocellatus* and 13.9 cms TL in the females. *C.xanthocephalus* with sexually differentiated testis was found to occur in the size class of 5 - 5.9 cms TL in the Kalpeni samples in the present study. Hence the estimated size at first maturity as 13.26 cms and 13.1 cms in *C.auriga* could be a little higher. This might be due to the inadequate number of fishes in different size groups at the different stages of maturity in the samples collected in the present study.

In all groups a single male, a linear size-dependent dominance system occurs, with the larger male dominating all females of the group as in *D.marginatus* (Fricke, 1980). Observations on the protogynous sex change of individuals that spawned as females to males after removal of the largest male in the group in *D.reticulatus* is reported by Schwarz and Smith (1990). Protogynous sex change in pomacentrids is also reported by Schwarz (1980) and Coats (1982). Histological evidence for protogynous hermaphroditism in *D.aruanaus* and *D.marginatus* is presented by Shpigel and Fishelson(1986). Protandrous hermaphroditism in pomacentrids is also reported by Moyer and Nakazono (1978a) and Fricke and Holzberg (1974). Transformation of Juvenile to subadult males, which can change either to male or female afterwards is reported by Hattori and Yamamuva (1995). Mating system plasticity also occurs in the sex changing damselfish *D.aruanus*, which may be solitary, monogamous or haremic or form mulitiple groups with promiscuous mating (Fricke and Holzberg 1974, Fricke and Fricke 1977). In *D.reticulatus*, Schwarz and Smith (1990) reported the presencec of small individuals with transforming gonads within social groups and have suggested that some of these individuals may become the dominant males in newly settled groups of smaller conspecifics. According to them all the individuals develop first as females and hence a newly settled group consists of females and Juveniles and the males come from outside. As the fishes grow larger, they must move to corals with larger interstices. Schwarz (1995) observed the movement of *D.reticulatus* between groups seeking oppurtunites to acquire corals of their own. According to Booth (1995) group members of *D.albisella* establish a dominance hierarchy based on size and the fishes leave these groups upon reaching mature size of 7 cms TL to enter the nearby adult population. Fricke (1980) also pointed out that the size of corals determines group size and male component. Based on the observations made during present study, it is suggested that being the largest of the colony, it may be the males that move to the other corals with less population or to non-populated corals. Sweatman (1985a) has shown that larvae of pomacentrids settle preferentially to corals occupied by conspecific adults. The newly settled larvae develop to females as proposed by Schwarz and smith (1990). In the colony which is now devoid of males, the females change their sex to males as proposed by Schwarz and smith (1990). The aspects discussed above justify the different values obtained for size at first maturity in contrast to the occurence of mature males and females in still smaller size groups and the occurence of males as the largest fish in any individual colony of *D.trimaculatus* and *D.reticulatus* in the present study.

Since the GSI values of the male chaetodons did not show much variation at different stages of maturity, it was irrevalent in determining the spawning season of these fishes. Ralston (1981) also was of the opinion that relatively large size of testes is unusual and is not characteristic of the family Chaetodontidae. The GSI values of the female chaetodons obtained in the present study agrees greatly with that of the female *C.austriacus* and *C.paucifasciatus* observed by Gharaibeh and Hulings (1990). The occurrence of Stage Ib females throughout the study period suggest threee aspects:-

1. The chaetodons spawn year round.

2. Chaetodons exhibit spawning migration to the reef ends for thhe spawning activity effecting the dispersal of the pelagic eggs to the open sea.

3. The less number of ripe fishes in the samples collected was due to this spawning migration of chaetodons.

In contrast to the temperate marine fishes and those of higher latitudes, tropical marine fishes breed more or less all year round with little or no apparent seasonal pattern (Qasim 1956). Ralston (1981) reported spawning of *C.miliaris* taking place from about January to May with a peak during February and March. Occurence of ripe *C.capistratus* , *C.striatus* and *C.ocellatus* in every month with the peak of spawning varying in different months has been reported by Aiken (1983). Spawning occurs daily, throughout all or most of the lunar cycles in the various angel fishes (Moyer and Nakazono 1978, Moyer *et al.* 1983). Ralston (1981) observed no relationship between lunar phase and GSI in *C.miliaris*. Vijay Anand (1994) also reported *C.collare, C.melannotus, C.octofasciatus* and *C.trifasciatus* as continuous spawners. Factors such as temperature, day light, lunar periodicity and weather conditions such as moonsoons are important in determinig reproductive cycles in fishes and may account for much of the geographic variation in breeding times among coral reef fishes (Russel *et al.* 1977).

All members of the family Chaetodontidae are presumed to be broad cast spawners with pelagic eggs (Breder and Rosen, 1966). Most coral reef fishes with pelagic eggs spawn at times and places that increase the prospect of offshore transport of eggs to avoid shallow water areas with high egg and larval predation (Randall 1961, Randall and Randall 1963, Barlow 1975a, Choat and Robertosn 1975, Warner *et al.* 1975, Colin 1978, Colin and Clavijo 1978, Johannes 1978 and Lobel 1978). Most of the mobile reef fishes such as Serranidae, Mullidae, Pomacanthidae, Chaetodontidae, Acanthuridae, Labridae and Scaridae make brief spawning migration to the edge of the reef, often around a pass or to the down current side of a seaward extension of the reef as reported by Barlow (1981). Even small wrasses such as *Thalassoma bifasciatum* swim as far as 500 m to spawn (Robertson and Hoffman 1977). Hensley *et al.* (1994) experimentally proved the spawning migration of *T.bifasciatum* effecting rapid transport of eggs from the reef areas.

In the pomacentrids, occurrence of mature fishes year round , the occurence of Ib stage maturity throughout the study period and the distribution of GSI values indicate *D.trimaculatus* and *D.reticulatus* are continous spawners. Pressley (1980) reported the influence of lunar and tidal cycles on the spawning of the pomacentrid, *Microspathodon chrysurus*. Daily, monthly and semilunar breeding rhythms were observed in the reproduction of *Pomacentrus flavicauda* and *P.wardi* by Doherty (1983). Strong semilunar spawning cycle is exhibited by the pomacentrid, *Glyphidodontops biocellatus* (Thresher and Moyer 1983). Multiple synchronous spawning in *Chromis caeruleus* was reported by Russel(1971). He also observed some individuals of this pomacentrid fish spawning 2 or 3 times over a period of four months. Vijay

Anand (1994) reported continous spawning in *D.trimaculatus*. Johannes (1978) suggested variations in breeding peak with reference to seasonal variations in the Ocean currents passing reefs in fishes having pelagic larval life. Pressley (1980) suggested different patterns of spawning within the same species at various times and location.

The present study showed significant relation between fecundity and total weight of the fish and fecundity and ovary weight. Ralston (1981) obtained a quadriatic relationship between fecundity and weight of fish in *C.miliaris*, instead of the expected linear function of weight. He also reported approximately 180000 eggs in *C.miliaris* of size between 120 and 130 mm SL. Fecundity of 114 X 10^3 is reported in *C.auriga* by Gharaibeh and Hulings (1990). Vijay Anand (1994) reported fecundity in *C.collare* between 2763 and 31065. The observation that larger fishes with relatively less number of eggs than that found in smaller fishes made in the present study is also reported by Aiken(1983), who observed variation in fecundity with respect to size of the fishes in *C.capistratus*, *C.striatus* , *C.ocellatus* and *C.sedentarias*.

Nearly spherical eggs 0.73 by 0.75 mm has been reported in *C.aculeatus* (Colin and Clavijo 1988). Ova diameter in *C.collare* and *C.melannotus* as 0.93 mm and in *C.octofasciatus* as 0.74 mm was reported by Vijay Anand (1994).

No work was found in the literature to support the observations made on the fecundity studies in *D.trimaculatus* and *D.reticulatus*. Wide variation in the fecundity in relation to total length and body weight of *Chromis caerulus* was reported by Madan Mohan *et al.* (1986b). They also reported fecundity of *C.caeruleus* as 4000 - 8000. Fecundity of *D.aruanus* as 2125 - 7157 was reported by Pillai *et al.*(1985a). Description of eggs in pomacentrids is compiled by Breder and Rosen (1966). Pomacentrid eggs are described as elongated and demersal. Demersal eggs in *C.dispulis* is also reported by Kingsford (1985). Oval and adhesive eggs of *D.trimaculatus* having 0.018 inches is reported by Garnaud (1957a and b) as quoted by Breder and Rosen (1966). In the pomacentrid *Eupomacentrus leucorns*, eggs are elliptical with 0.85 mm length and 0.45 mm width in *E.leucostictus* eggs were 0.8 mm long and 0.4 mm wide and in *Chromis notatus* width was between 0.55 and 0.60 mm and length between 0.74 and 0.78 mm. Swerdloff (1970) reported small, elliptical eggs with egg stalk ranging in length from 0.6 and 0.66 mm and width from 0.42 and 0.49 mm in *C.caeruleus*. Madan Mohan *et al.*(1986b) reported ova diameter as 0.49 mm in *C.caerulus* and Pillai *et al.*(1985a) reported the size of ova of *D.aruanus* at stage VI as 0.49 mm. The ova diameter in *D.trimaculatus* has been reported as 0.74 mm by Vijay anand (1994). Eggs of 0.9 X 0.6 mm size with stalk are reported by Russel (1971) in *C.dispulis*. Slightly larger eggs of 1.2 X 0.7 mm eggs are reported in *P.flavicauda* and those with 1.6 X 0.9 mm in *P.wardi* by Doherty (1983).

PLATE 39

Percentage occurrence of males females and indeterminates in various size groups from Minicoy and Kalpeni

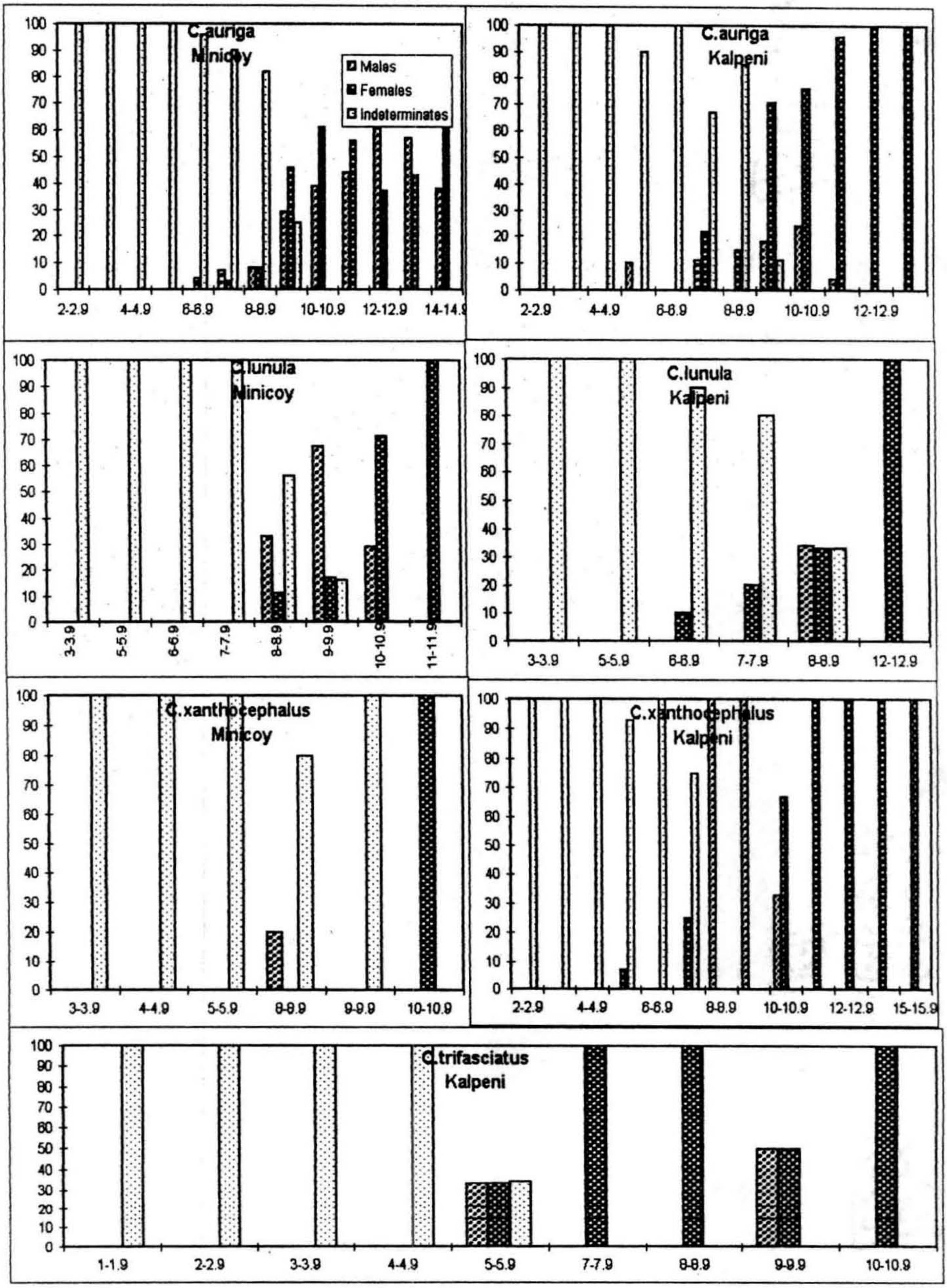
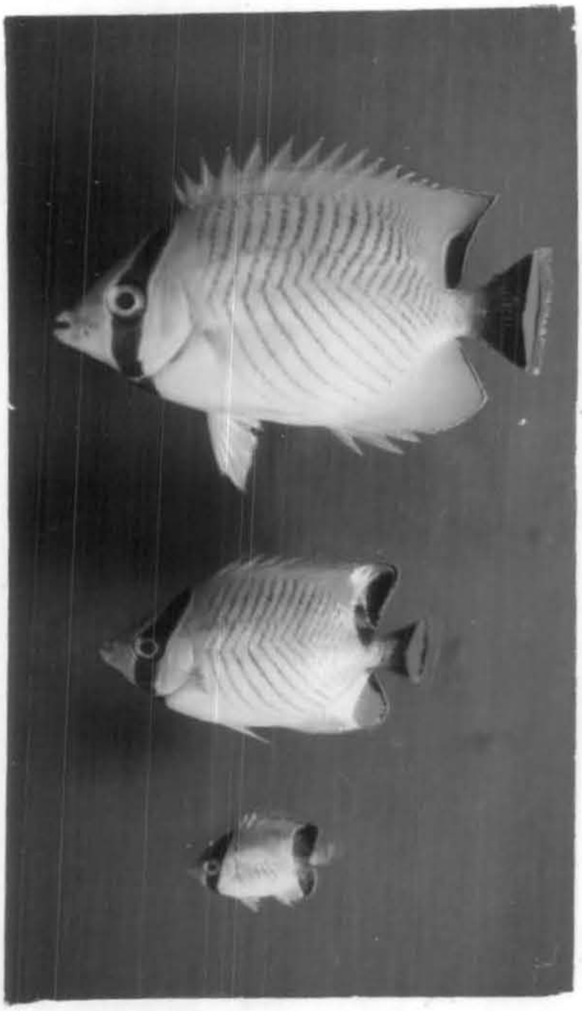


PLATE 40



A

B

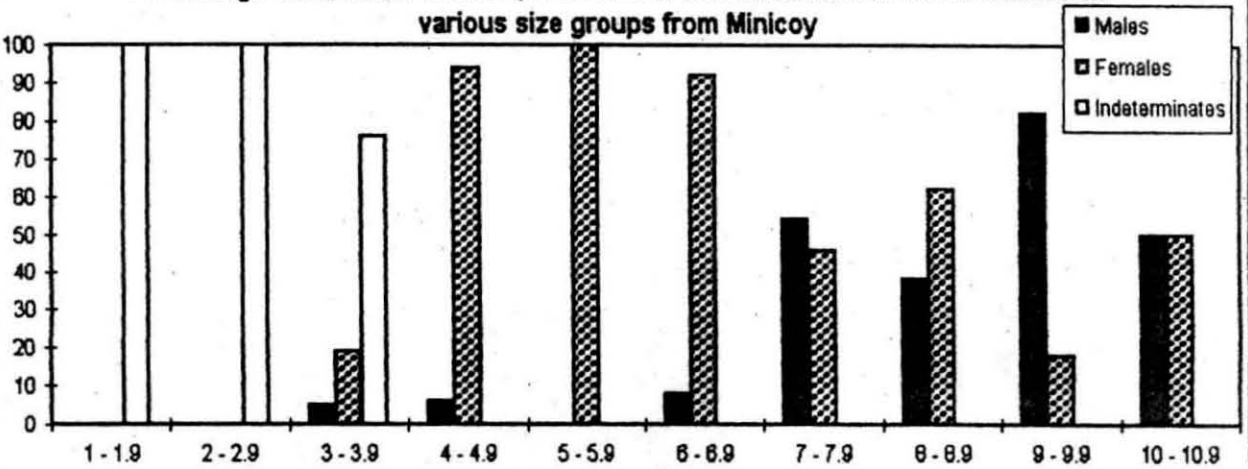
Chaetodon in different sizes.

A . C. trifascialis – 9.9 cm.
" – 6.7 cm.
" – 3.2 cm.
B . C. auriga – 13.4 cm.
" – 6.8 cm.
" – 3.0 cm.
C . C. trifasciatus – 8.3 cm.
" – 7.2 cm.
" – 4.9 cm.

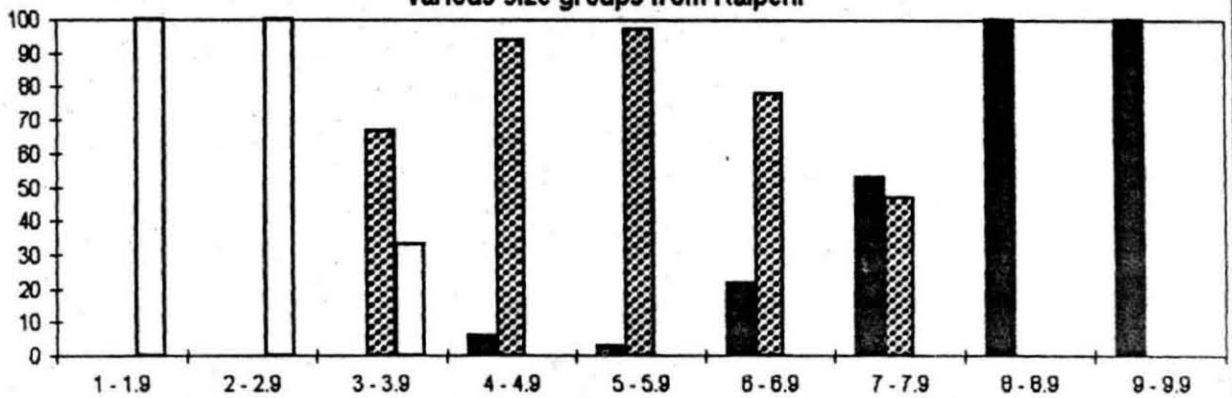
C

PLATE 41

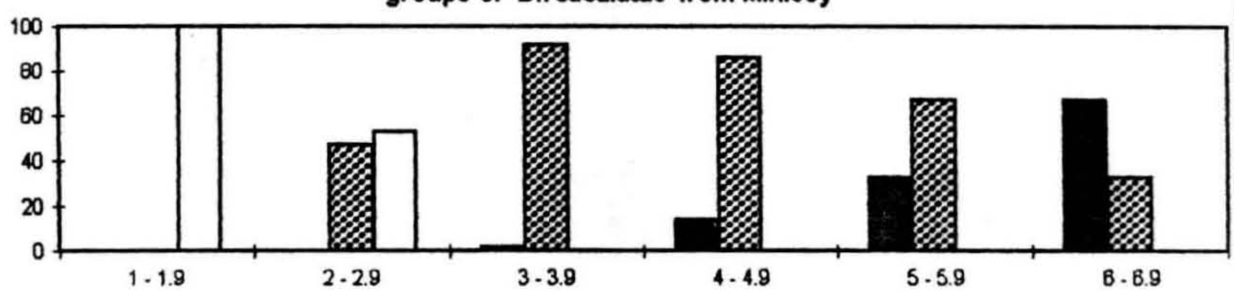
Percentage occurrence of males, females and indeterminates of *D.trimaculatus* in various size groups from Minicoy



Percentage occurrence of males, females and indeterminates of *D.trimaculatus* in various size groups from Kalpeni



Percentage occurrence of males, females and indeterminates in various size groups of *D.reticulatus* from Minicoy



Percentage occurrence of males, females and indeterminates in various size groups of *D.reticulatus* from Kalpeni

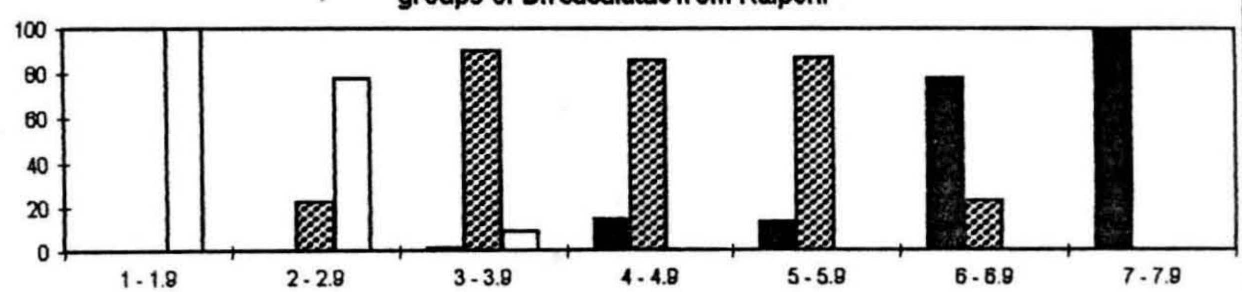
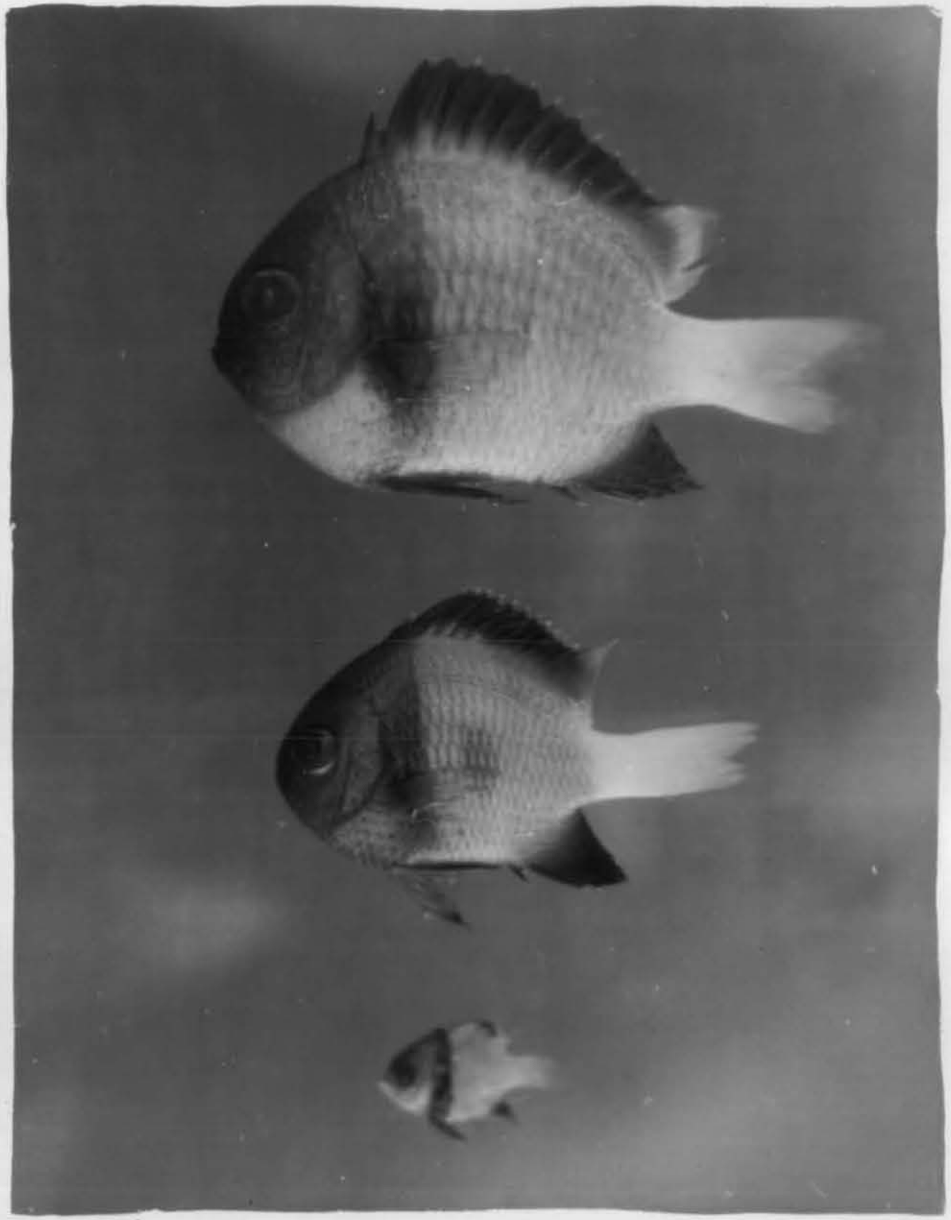
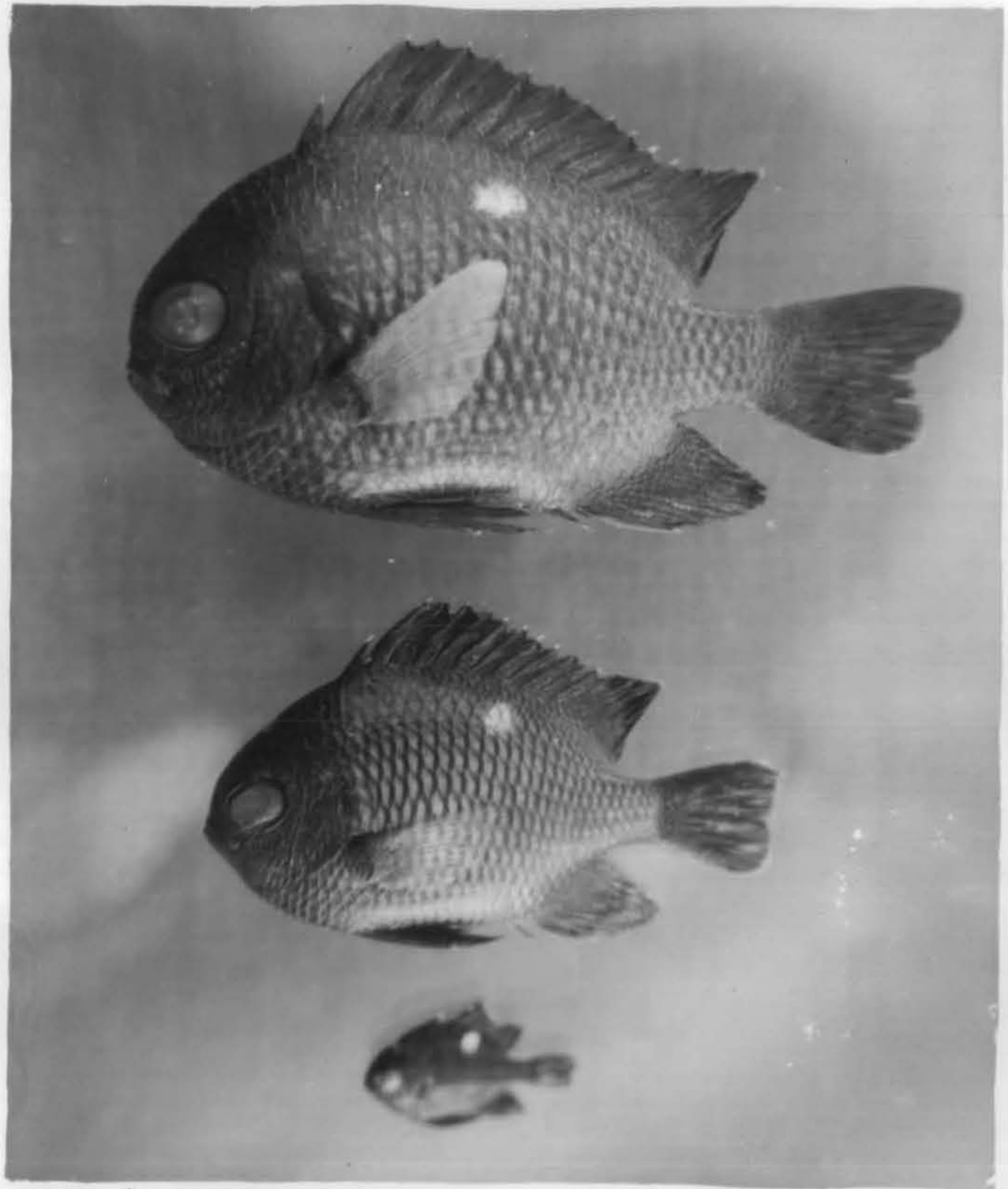


PLATE 42





A. D. reticulatus – 4.7 cm.
,, – 5.4 cm.
,, – 2.1 cm.

B. D. trimaculatus – 7.5 cm.
,, – 3.8 cm.
,, – 1.6 cm.

PLATE 43

Percentage occurrence of male and female C.auriga from Minicoy and Kalpeni

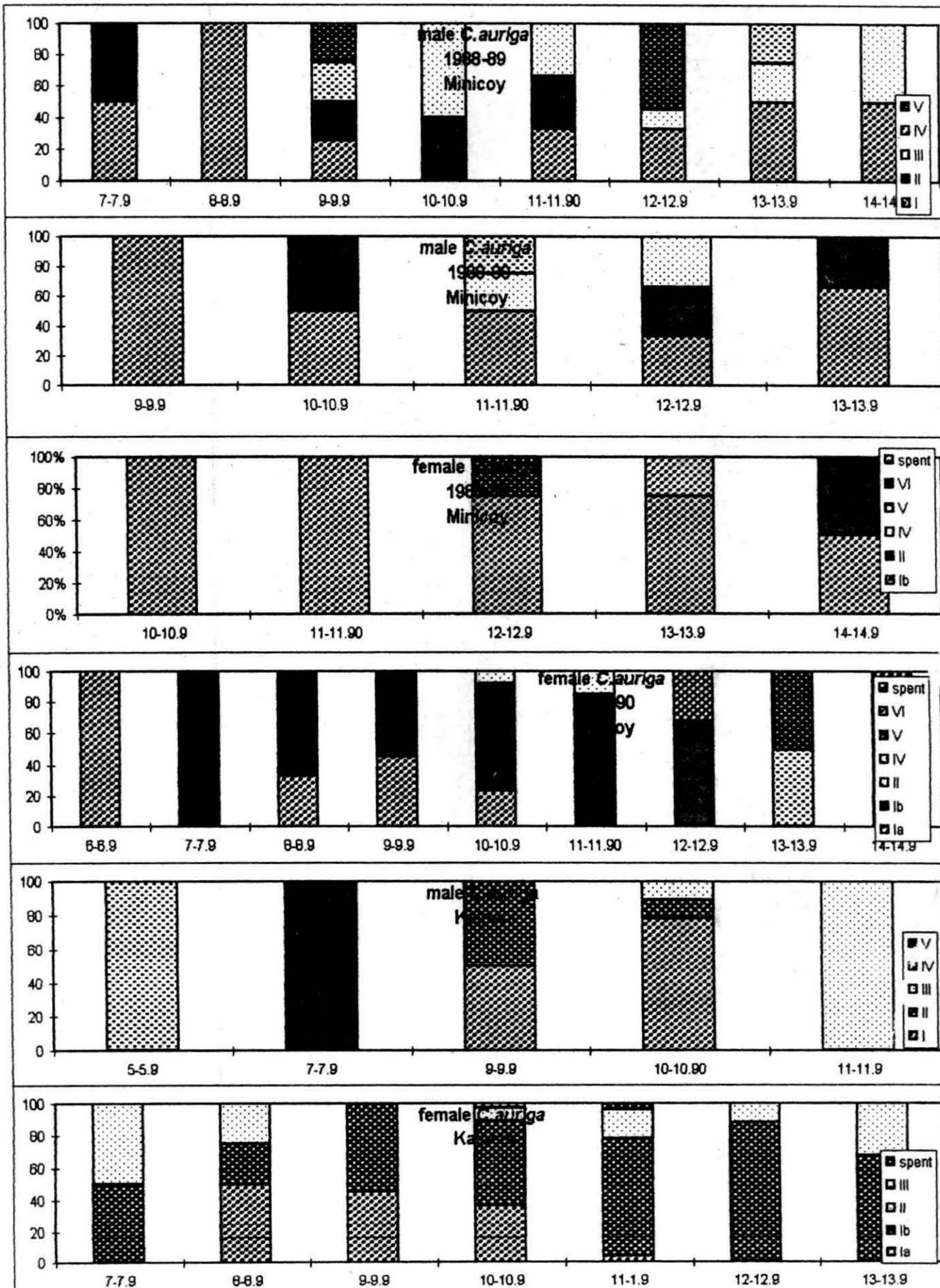


PLATE 44

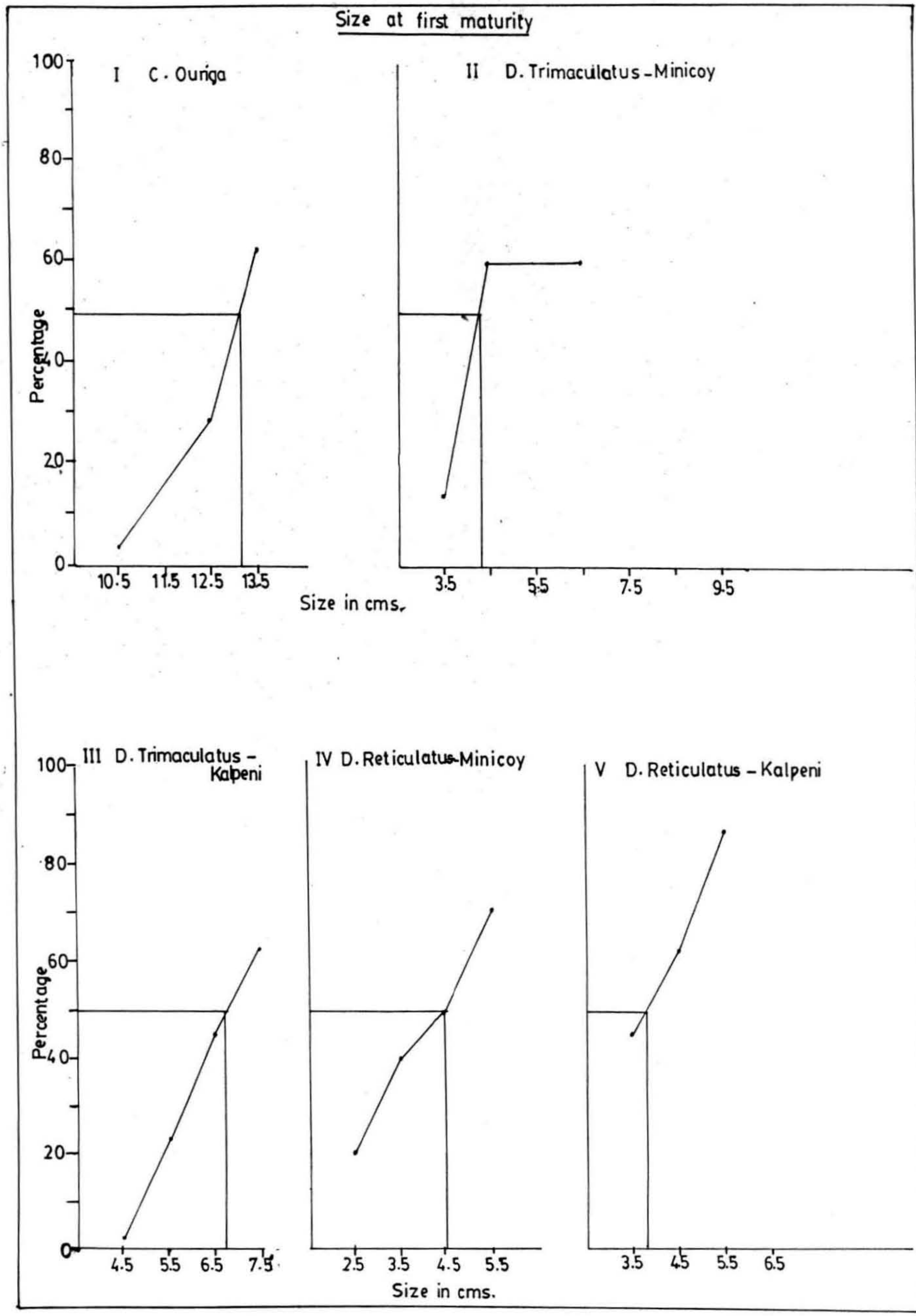

Size at first maturity
I C. Ouriga
II D. Trimaculatus - Minicoy
III D. Trimaculatus - Kalpeni
IV D. Reticulatus - Minicoy
V D. Reticulatus - Kalpeni
Percentage
Size in cms.
0
20
40
60
80
100
10.5
11.5
12.5
13.5
3.5
5.5
7.5
9.5
4.5
6.5
2.5

PLATE 45

Percentage occurrence of male and female *D.trimaculatus* and *D.reticulatus* from Minicoy and Kalpeni

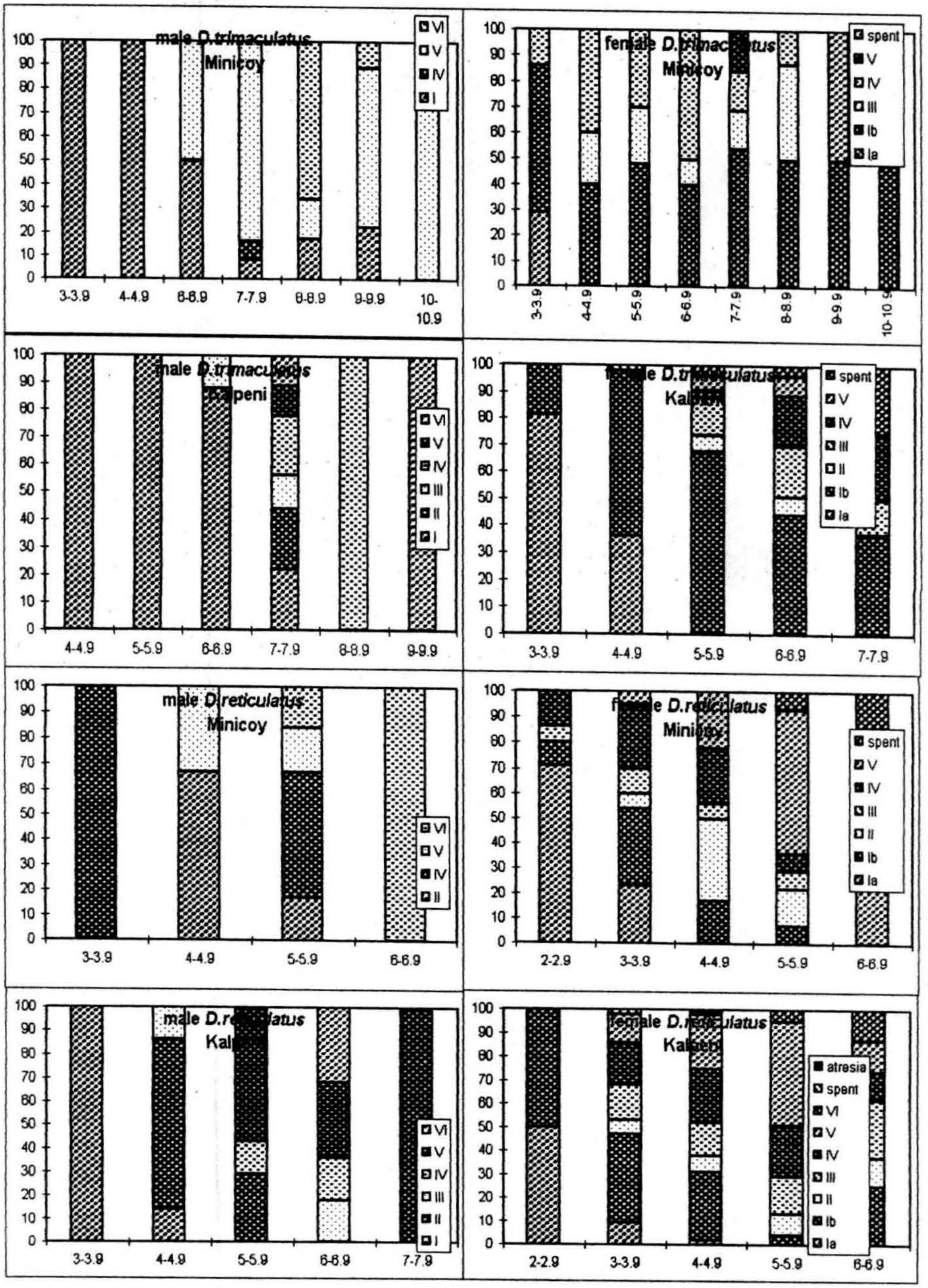
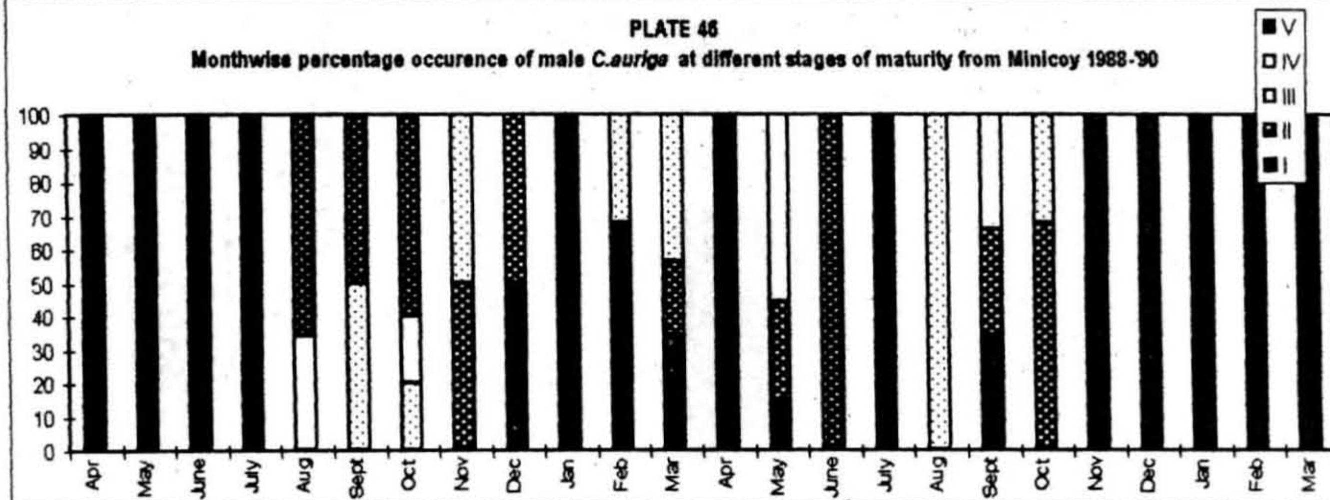
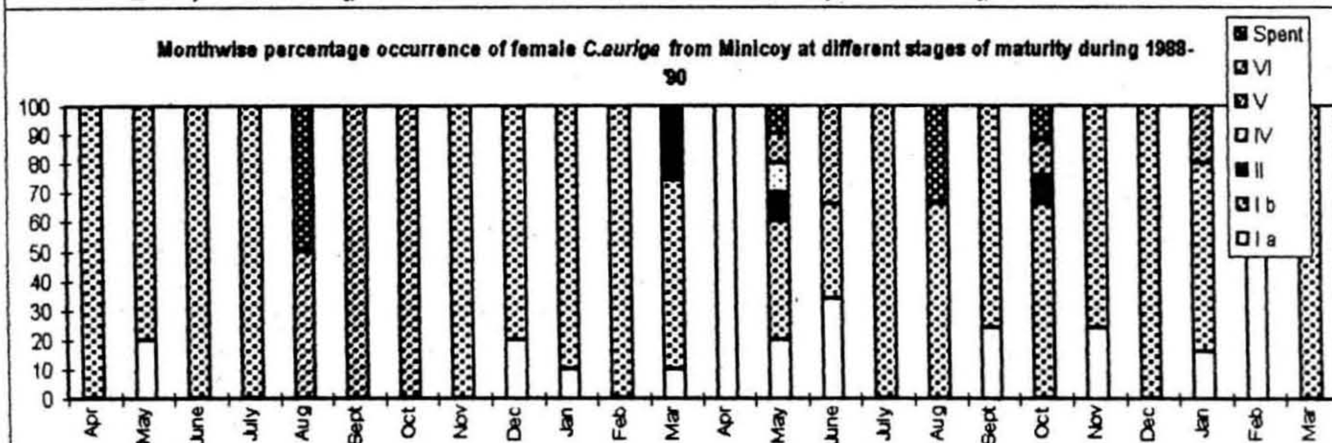


PLATE 46

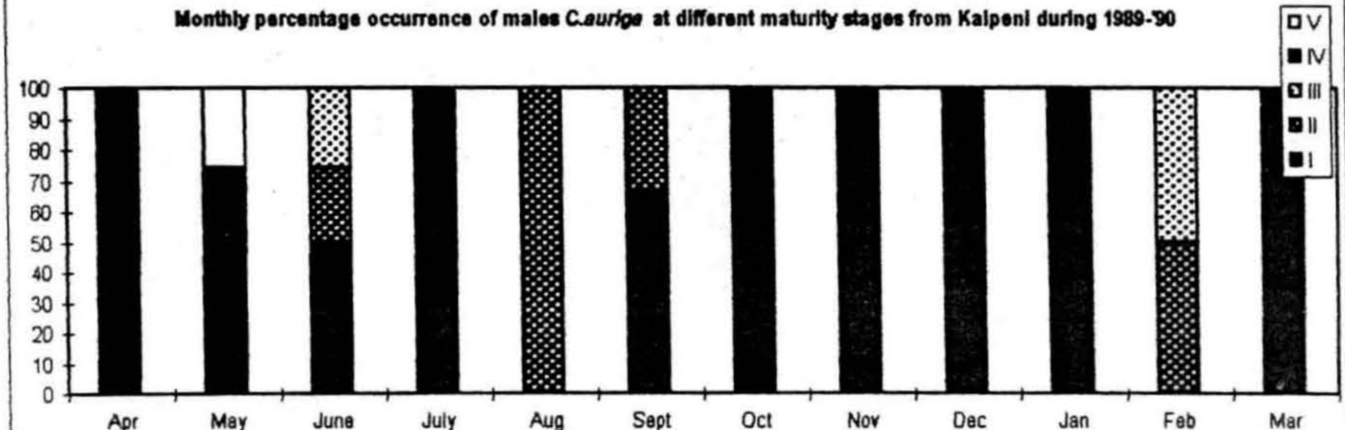
Monthwise percentage occurence of male *C.aurige* at different stages of maturity from Minicoy 1988-'90



Monthwise percentage occurrence of female *C.aurige* from Minicoy at different stages of maturity during 1988-'90



Monthly percentage occurrence of males *C.aurige* at different maturity stages from Kalpeni during 1989-'90



Monthwise occurrence of female *c.aurige* at different maturity stages from Kalpeni during 1989-'90

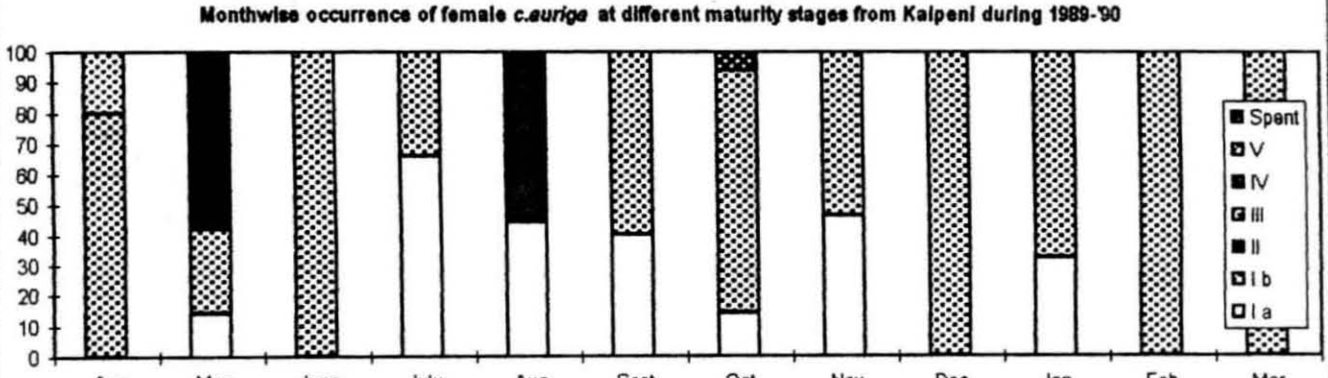
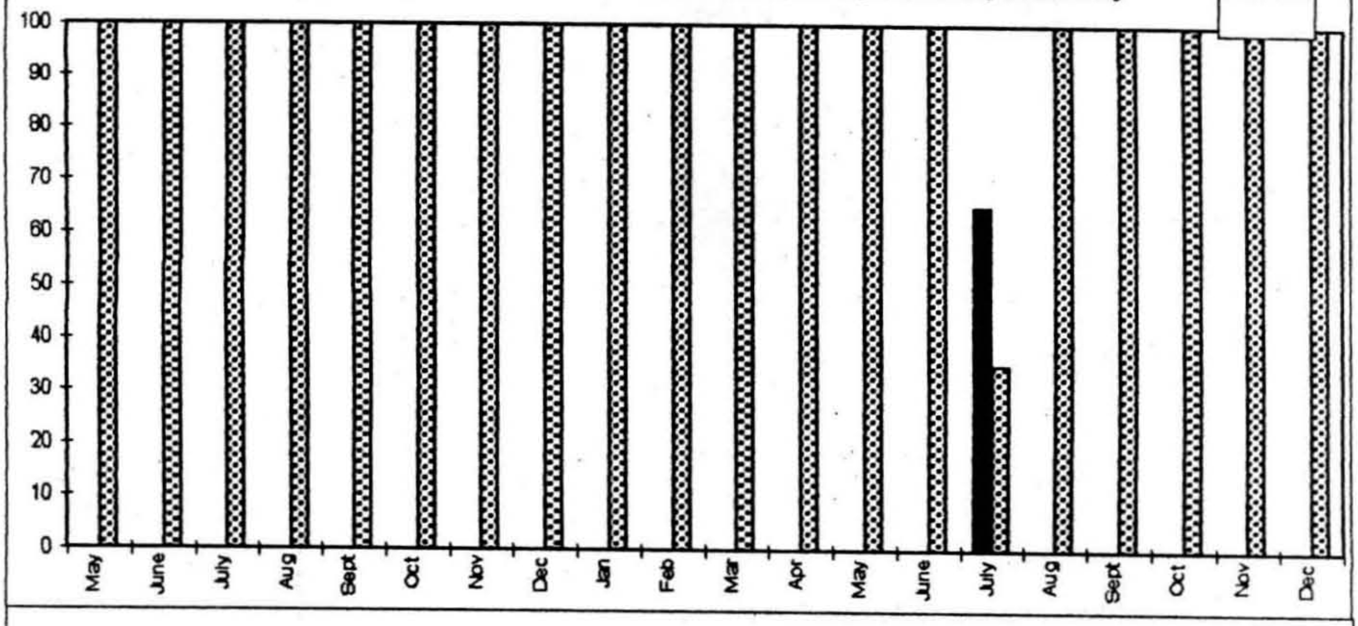
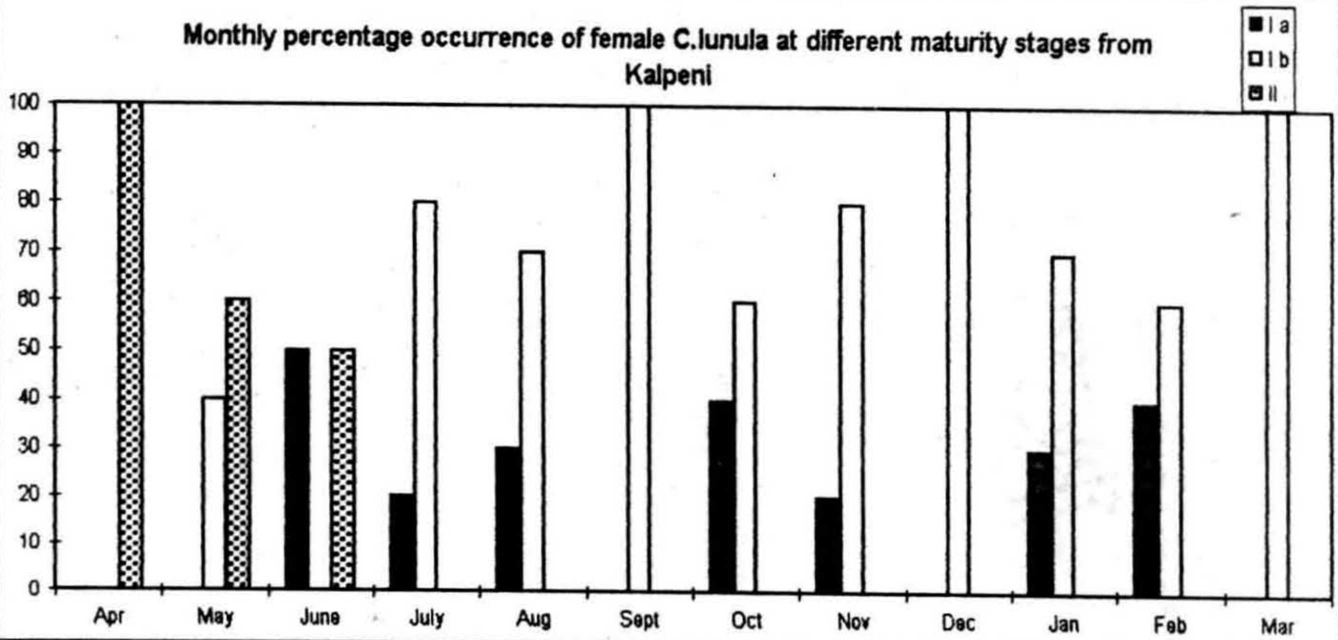


PLATE 47

Monthly percentage occurence of female *C.lunula* at different stages of maturity from Minicoy



Monthly percentage occurrence of female C.lunula at different maturity stages from Kalpeni



Monthly percentage ocurrence of female *C.xanthocephalus* at various maturity stages from Kalpeni

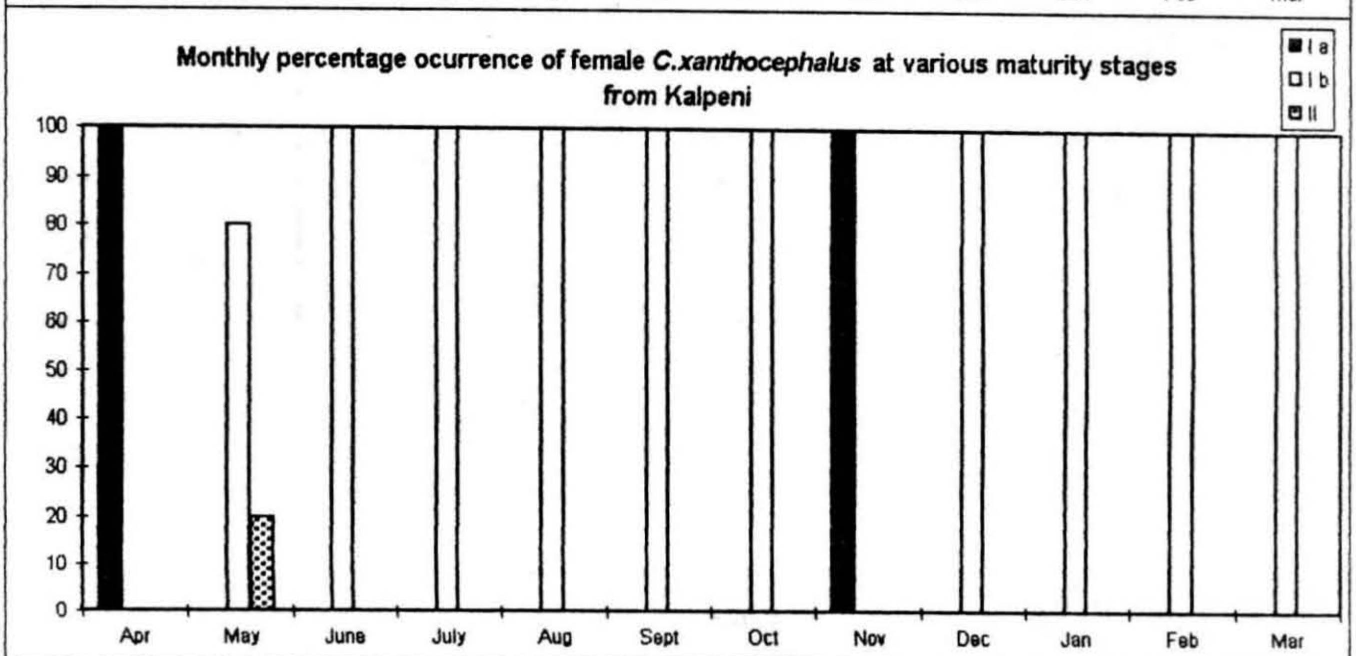
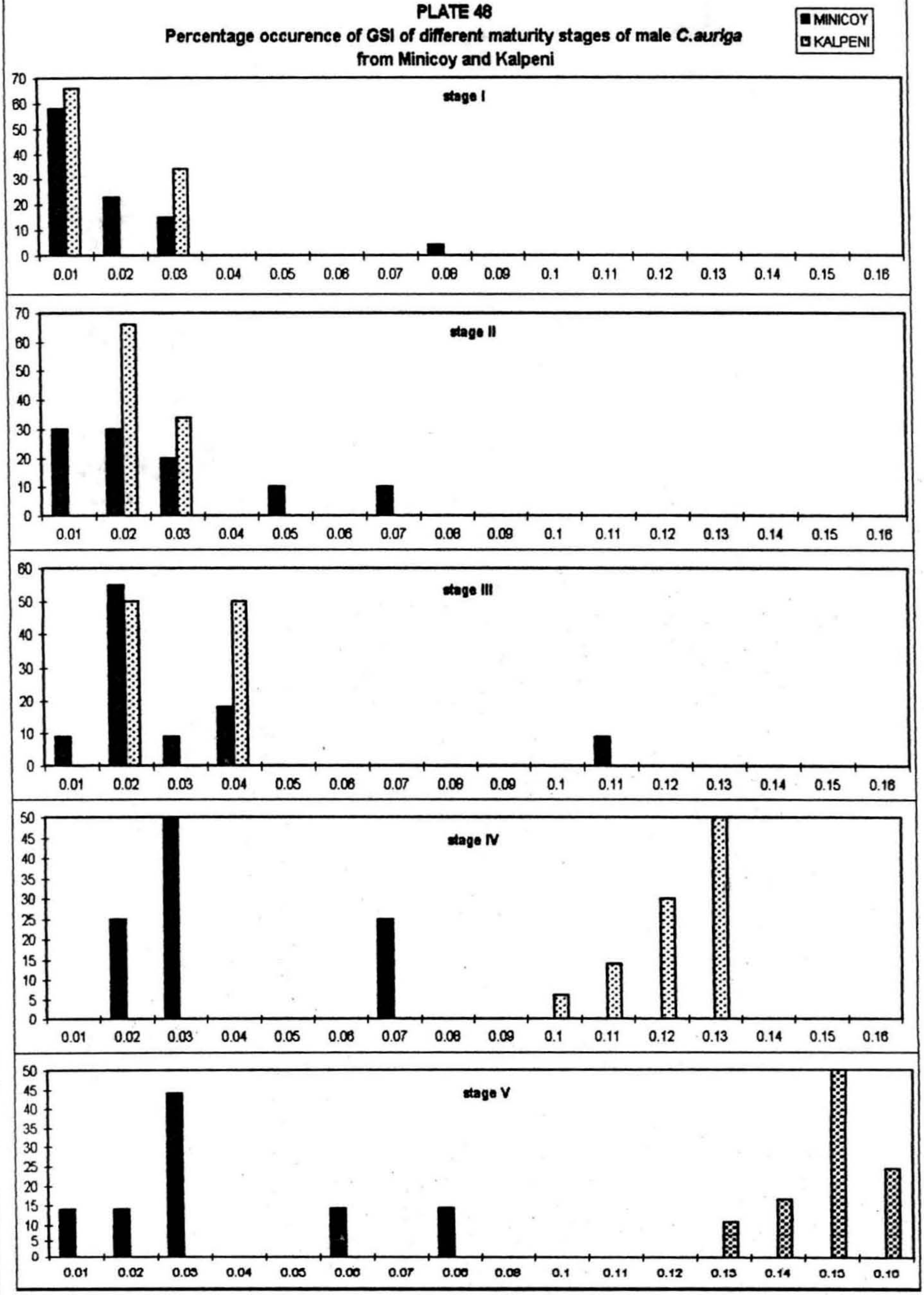


PLATE 48

Percentage occurence of GSI of different maturity stages of male *C.auriga* from Minicoy and Kalpeni



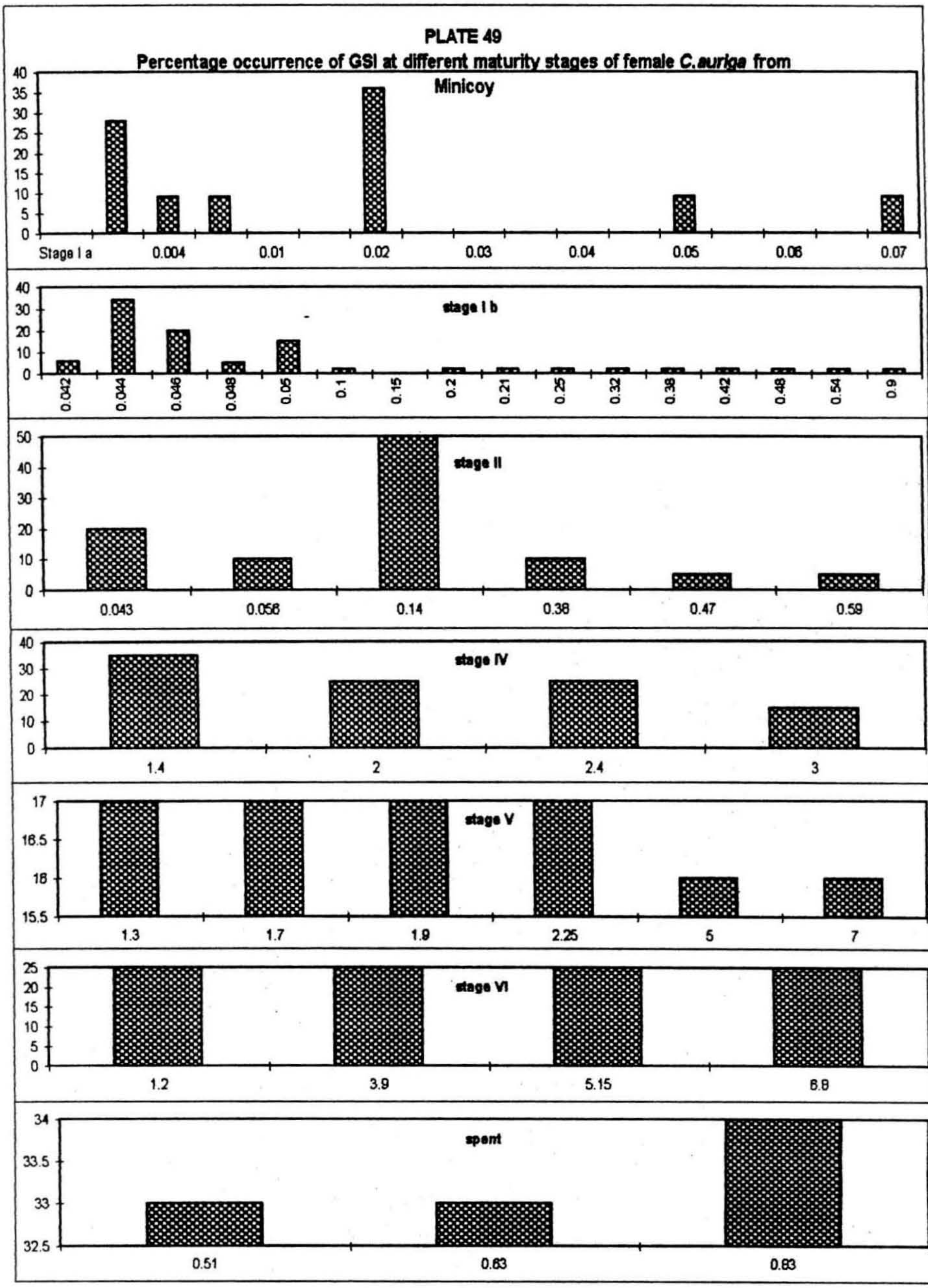


PLATE 49
Percentage occurrence of GSI at different maturity stages of female C.auriga from Minicoy
Stage I a
0.004
0.01
0.02
0.03
0.04
0.05
0.06
0.07
stage I b
0.042
0.044
0.046
0.048
0.05
0.1
0.15
0.2
0.21
0.25
0.32
0.38
0.42
0.48
0.54
0.9
stage II
0.043
0.056
0.14
0.38
0.47
0.59
stage IV
1.4
2
2.4
3
stage V
1.3
1.7
1.9
2.25
5
7
stage VI
1.2
3.9
5.15
6.8
spent
0.51
0.63
0.83

PLATE 50

Percentage occurence of GSI of different stages of maturity in female *C.auriga* from Kalpeni

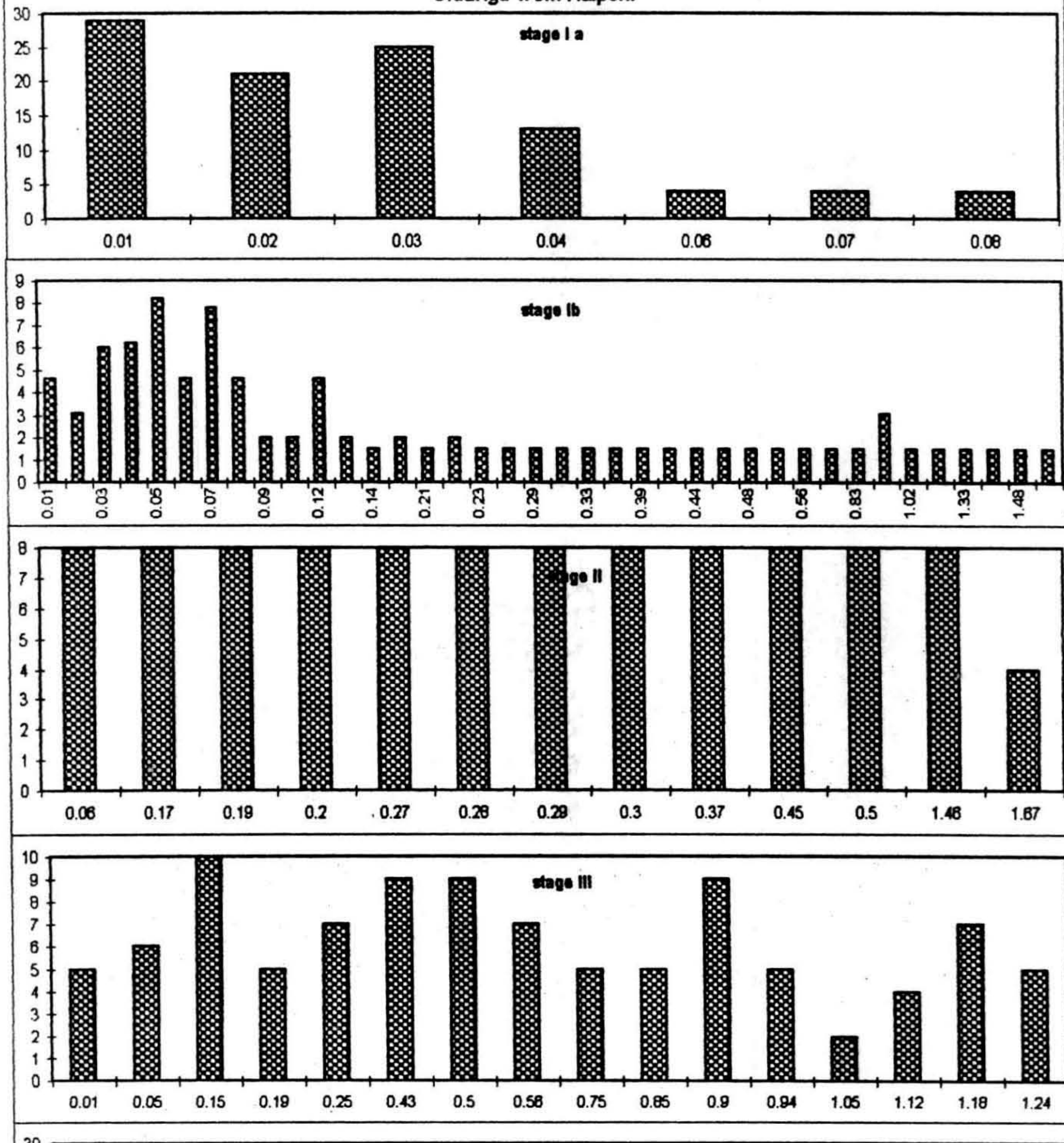


PLATE 51

Percentage occurence of GSI at different stages in various fishes from Minicoy and Kalpeni

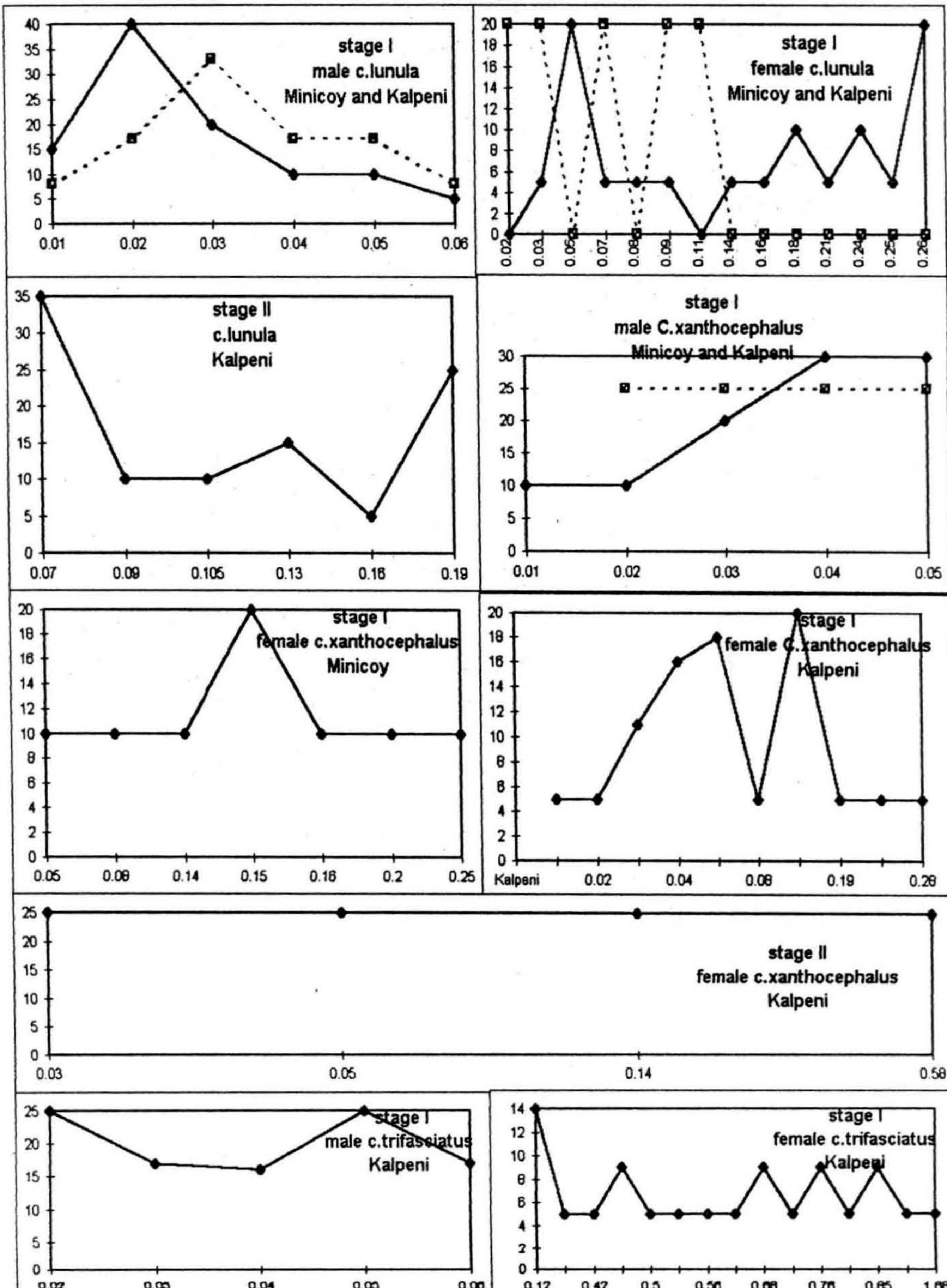
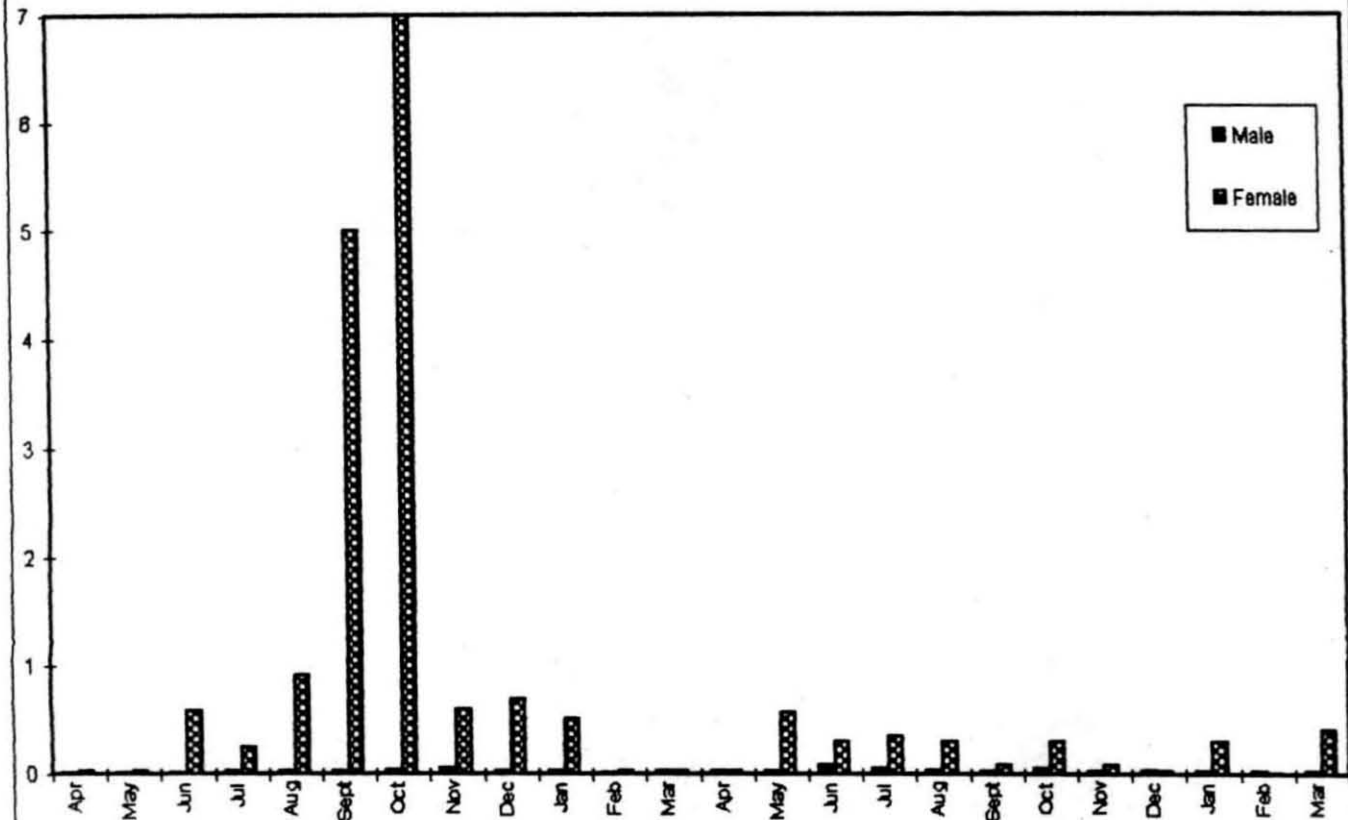


PLATE 52

Monthwise GSI of male and female *C.auriga* from Minicoy during 1988-'90



Monthwise GSI of male and female *C.auriga* from Kalpeni during 1989-'90

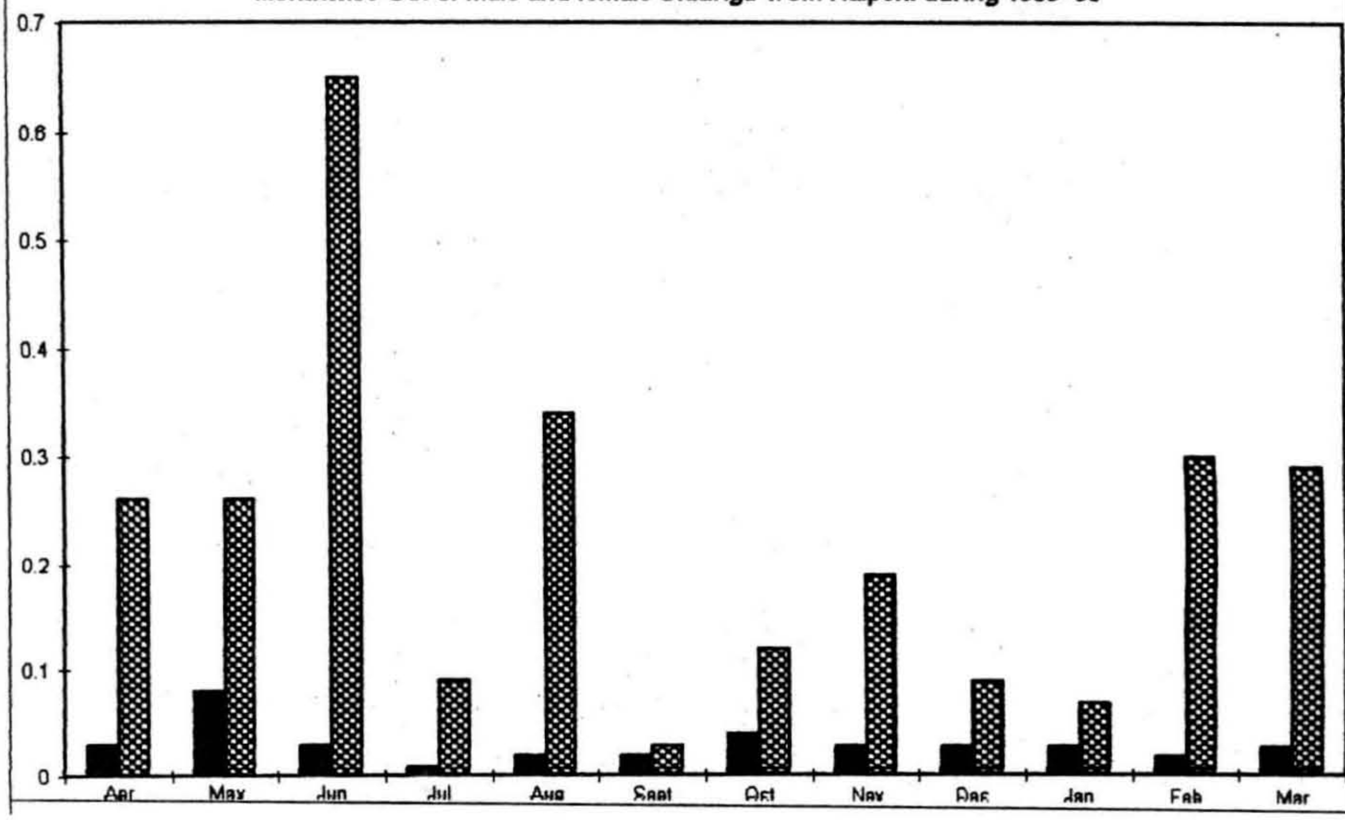
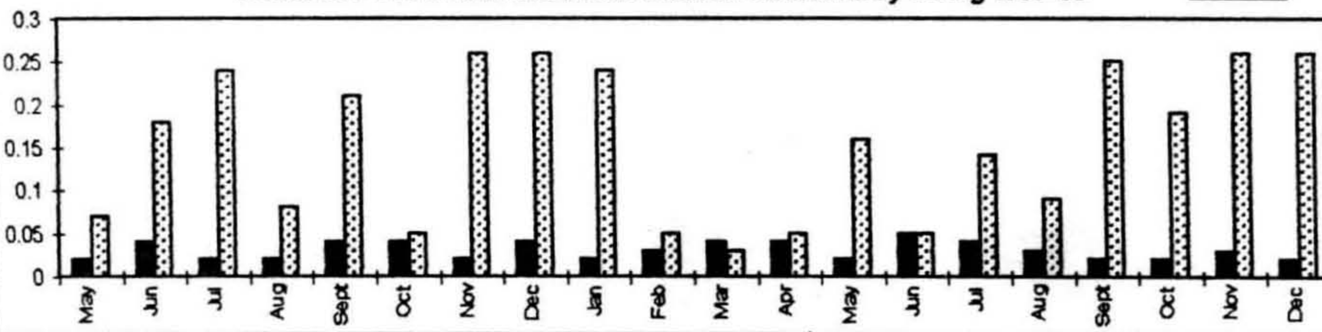
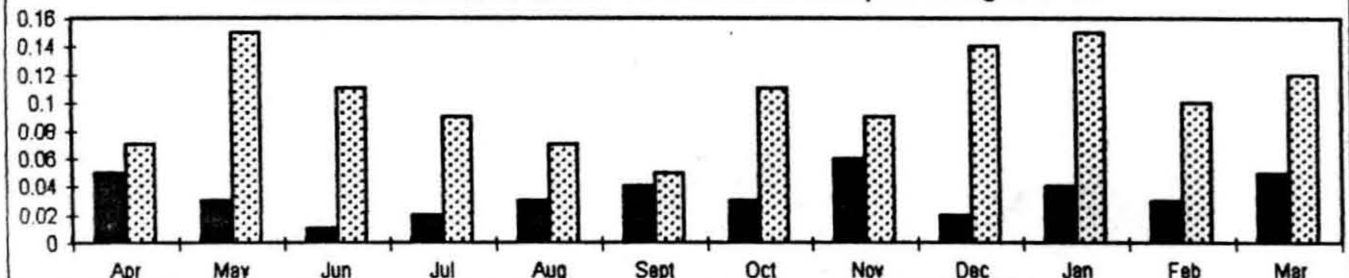


PLATE 53

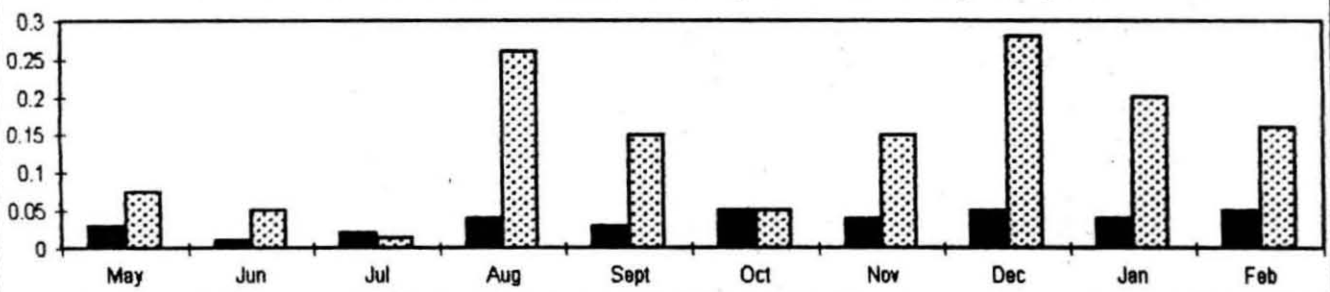
Monthwise GSI of male and female *C.lunula* from Minicoy during 1988-'90



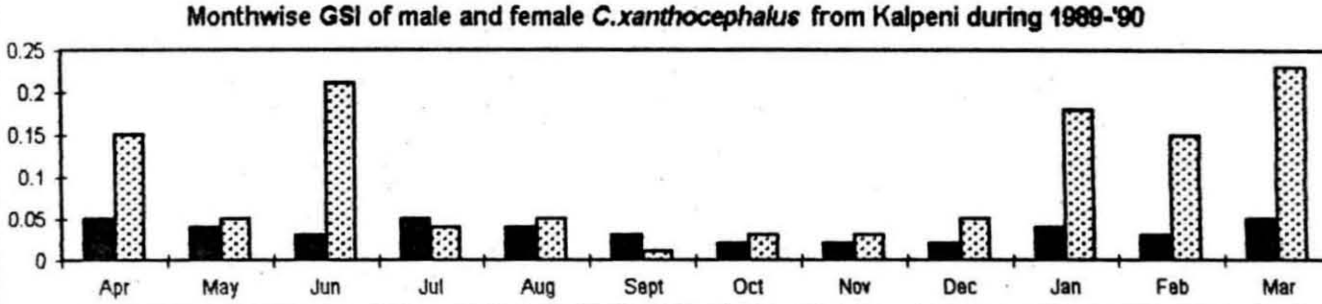
Monthwise GSI of male and female *C.lunula* from Kalpeni during 1989-'90



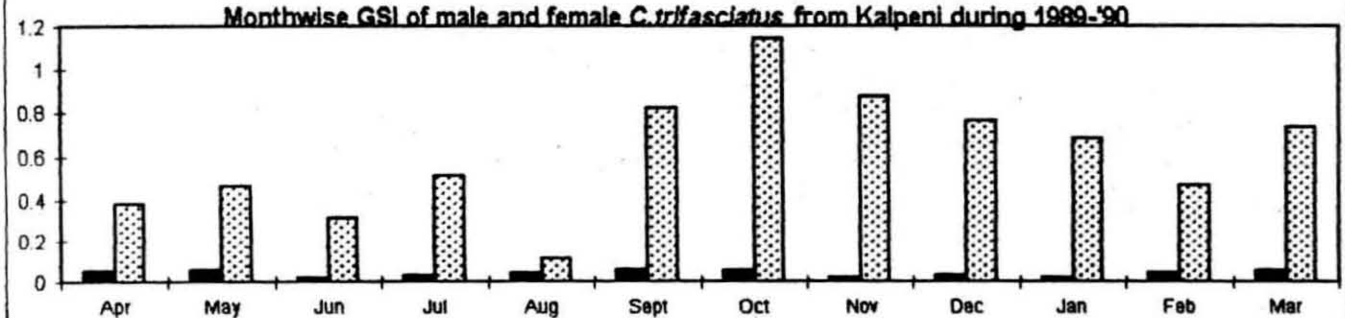
Monthwise GSI of male and female *C.xanthocephalus* from Minicoy during 1989



Monthwise GSI of male and female *C.xanthocephalus* from Kalpeni during 1989-'90



Monthwise GSI of male and female *C.trifasciatus* from Kalpeni during 1989-'90



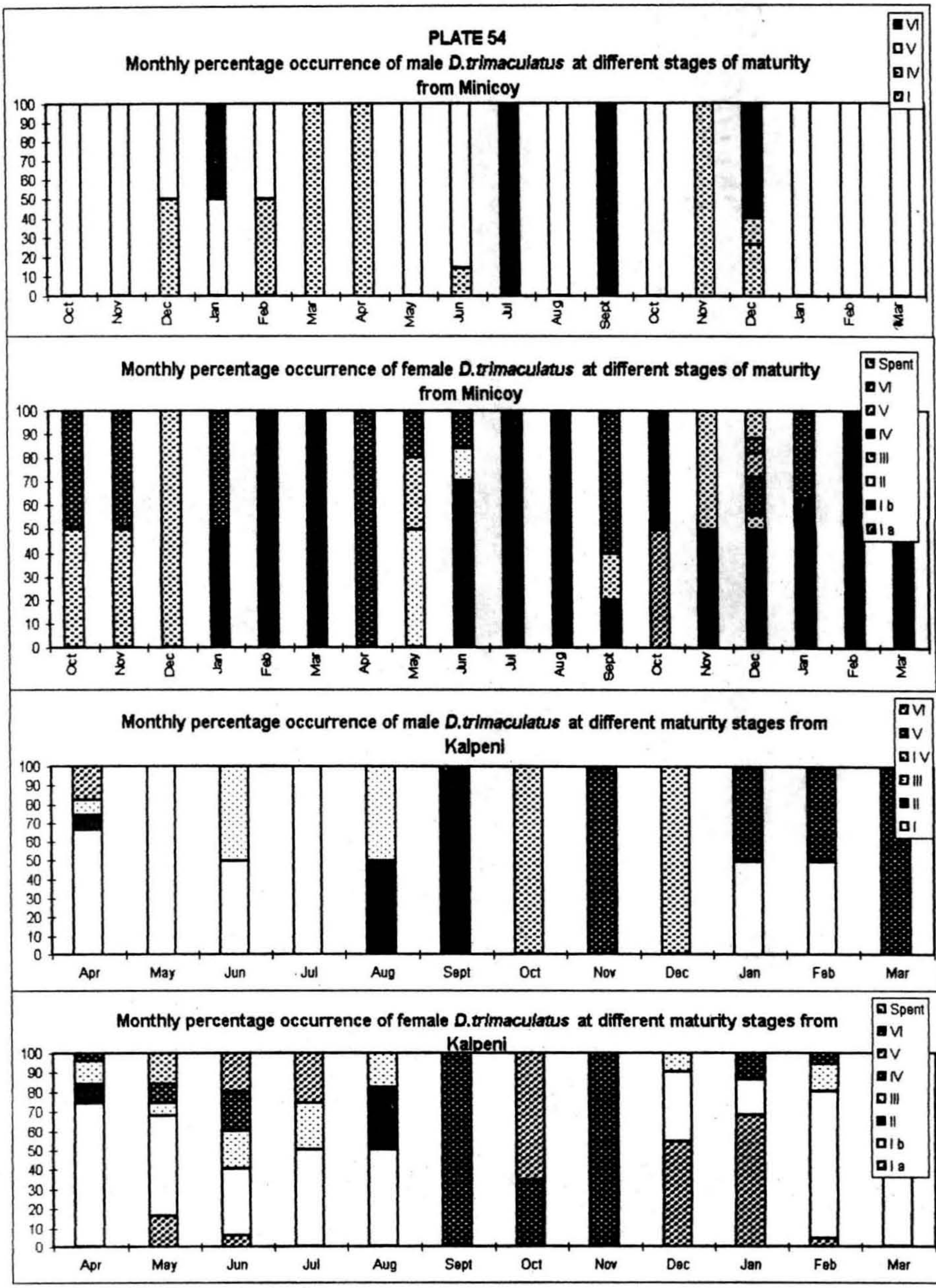
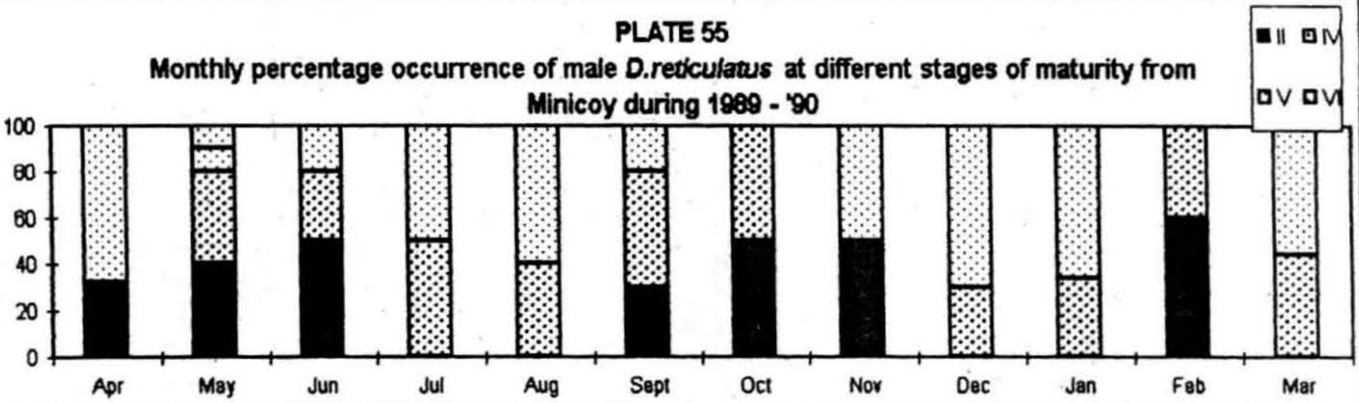


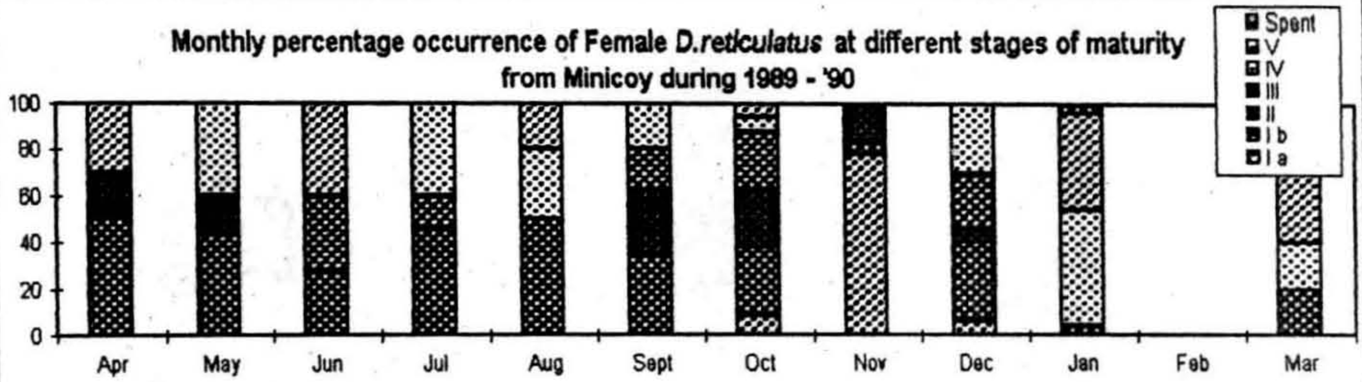
PLATE 54
Monthly percentage occurrence of male D.trimaculatus at different stages of maturity from Minicoy
VI
V
IV
I
100 90 80 70 60 50 40 30 20 10 0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar
Monthly percentage occurrence of female D.trimaculatus at different stages of maturity from Minicoy
Spent
VI
V
IV
III
II
I b
I a
100 90 80 70 60 50 40 30 20 10 0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar
Monthly percentage occurrence of male D.trimaculatus at different maturity stages from Kalpeni
VI
V
I V
III
II
I
100 90 80 70 60 50 40 30 20 10 0
Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar
Monthly percentage occurrence of female D.trimaculatus at different maturity stages from Kalpeni
Spent
VI
V
IV
III
II
I b
I a
100 90 80 70 60 50 40 30 20 10 0
Apr May Jun Jul Aug Sept Oct Nov Dec Jan Feb Mar

PLATE 55

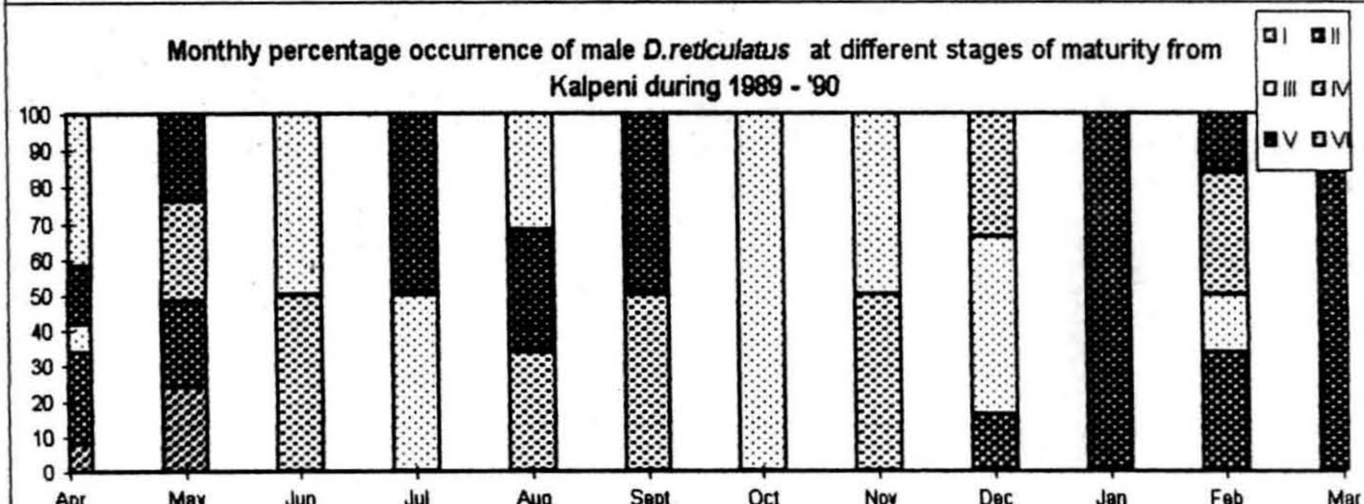
Monthly percentage occurrence of male *D.reticulatus* at different stages of maturity from Minicoy during 1989 - '90



Monthly percentage occurrence of Female *D.reticulatus* at different stages of maturity from Minicoy during 1989 - '90



Monthly percentage occurrence of male *D.reticulatus* at different stages of maturity from Kalpeni during 1989 - '90



Monthly percentage occurence of female D.recticulatus at different stages of maturity from Kalpeni during 1989 - '90

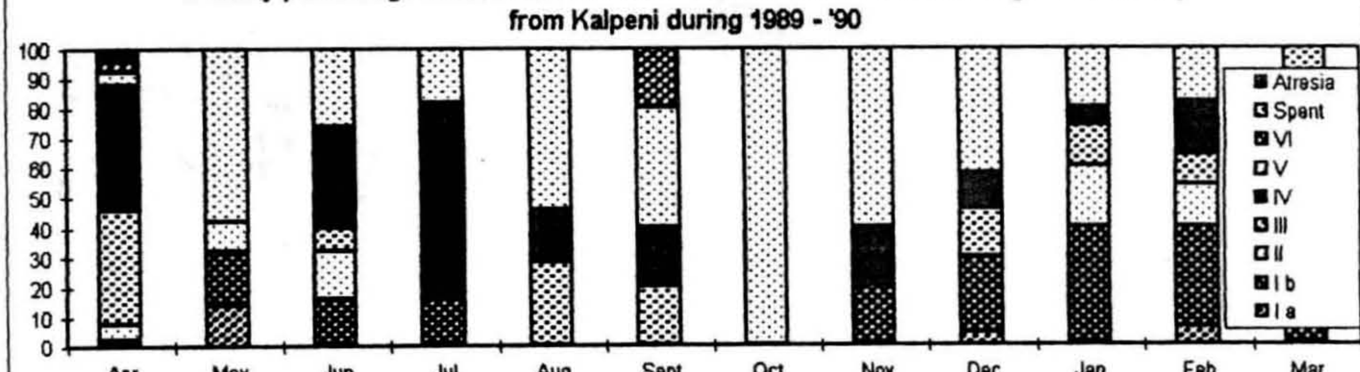


PLATE 56

Percentage occurrence of GSI of different maturity stages of male and female *D. trimaculatus* from Minicoy and Kalpeni

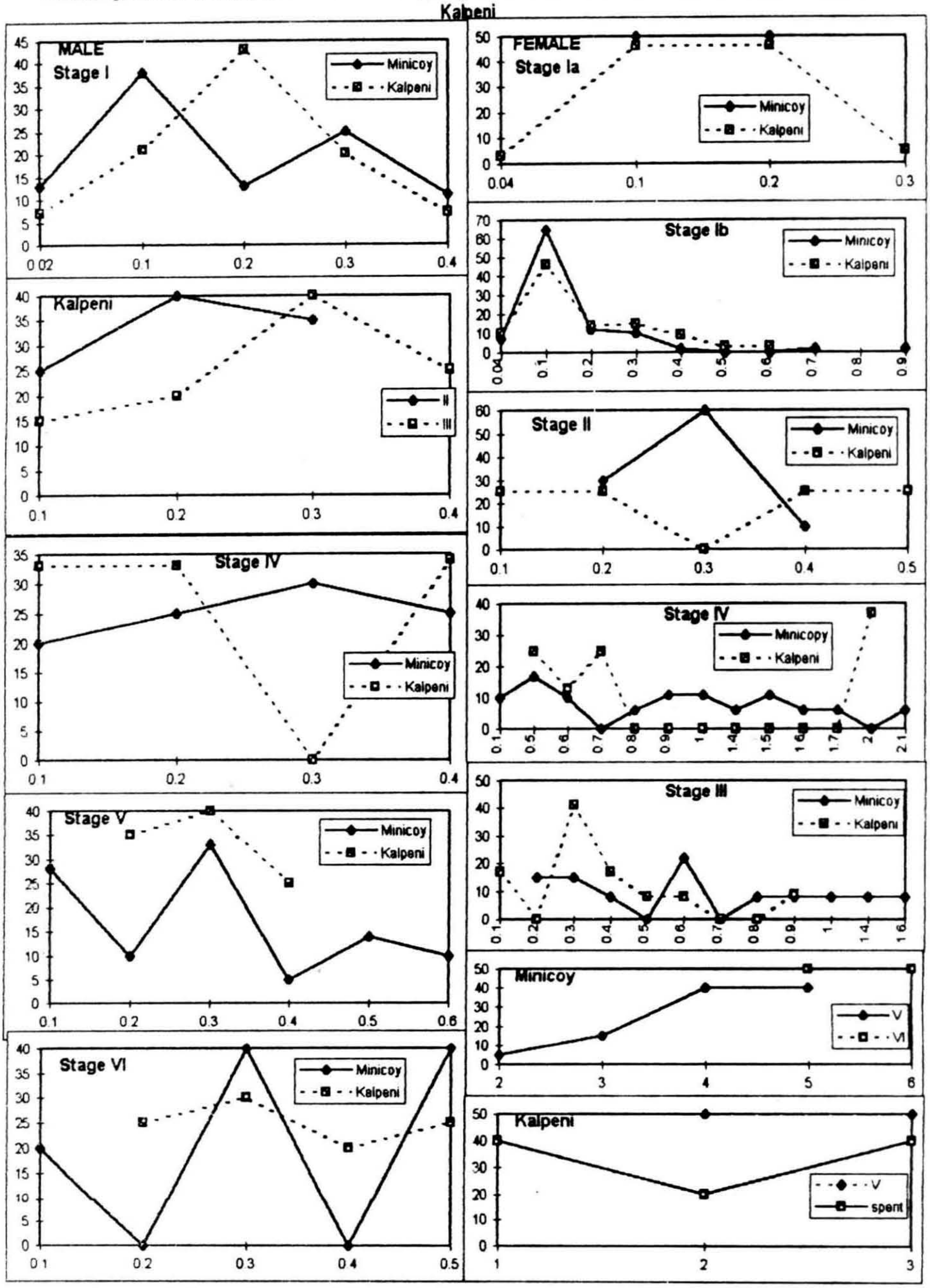
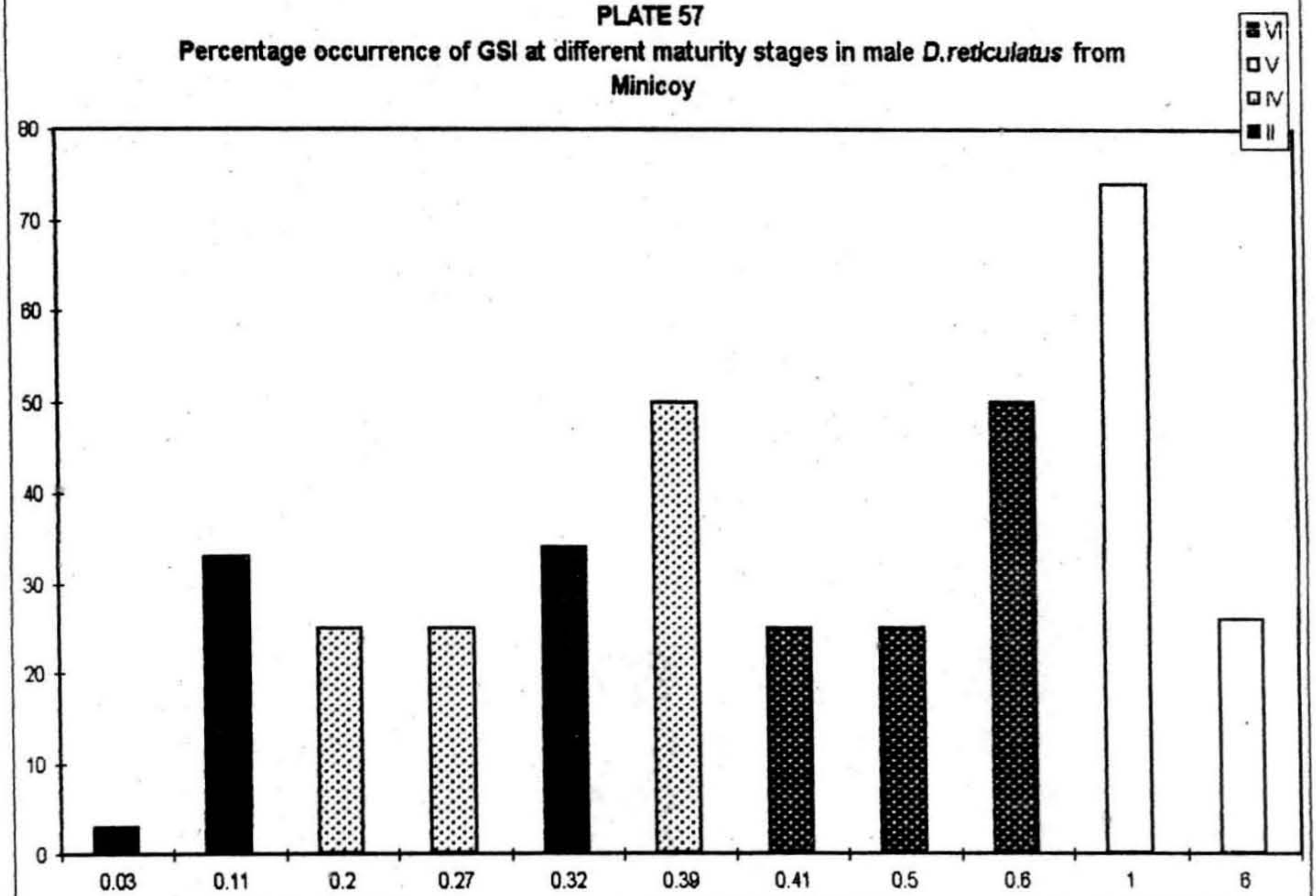


PLATE 57

Percentage occurrence of GSI at different maturity stages in male *D.reticulatus* from Minicoy



Percentage occurrence of GSI at different maturity stages in female *D.reticulatus* from Minicoy

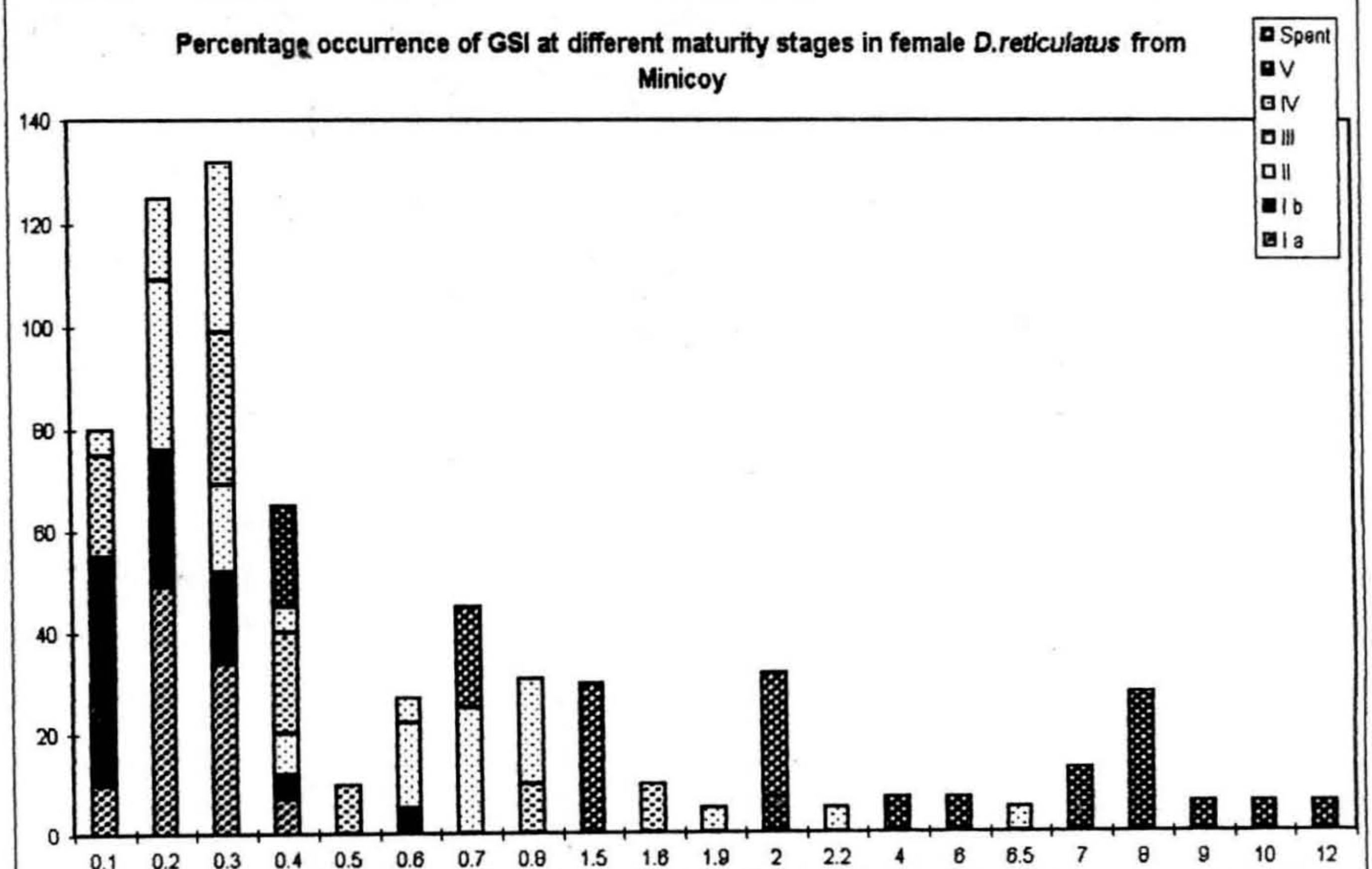
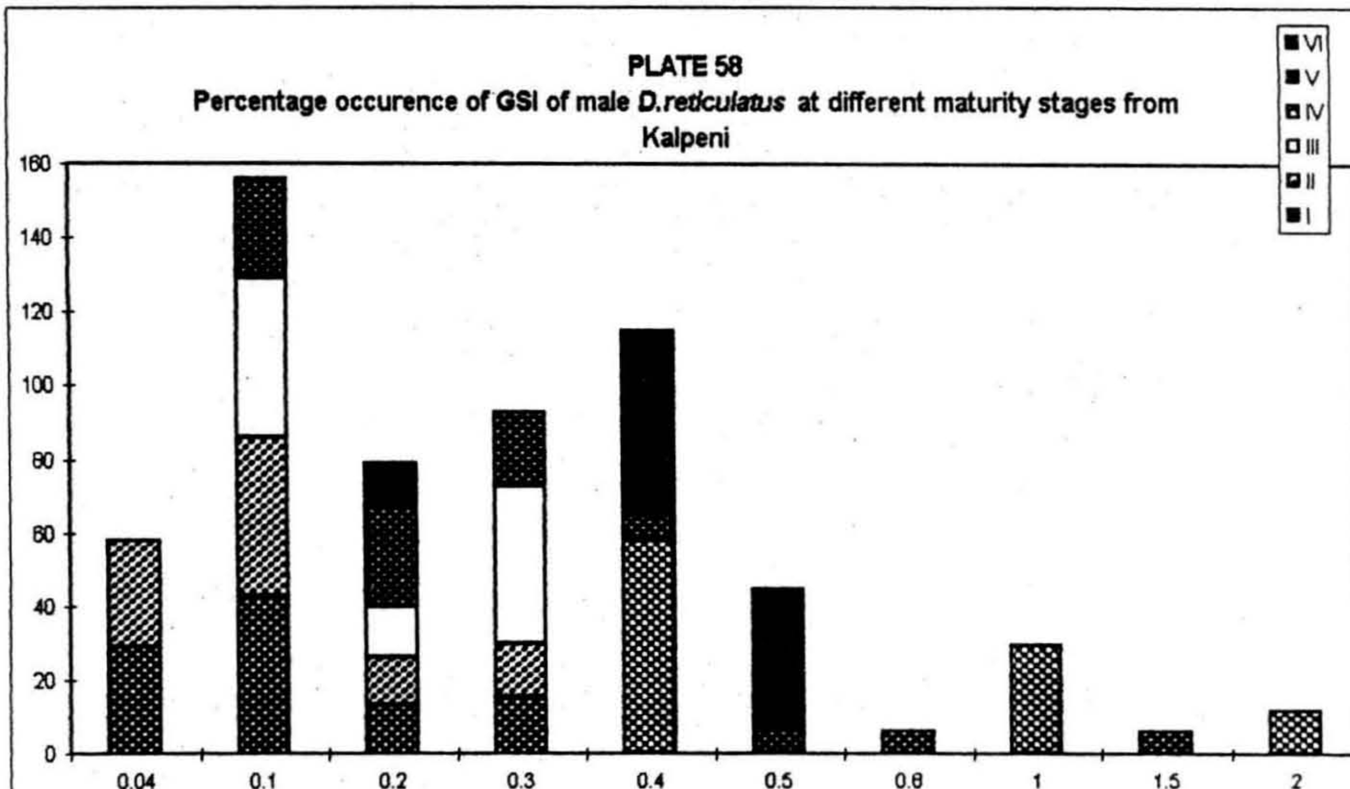


PLATE 58

Percentage occurence of GSI of male *D.reticulatus* at different maturity stages from Kalpeni



Percentage occurrence of GSI of female *D.reticulatus* at different maturity stages from Kalpeni

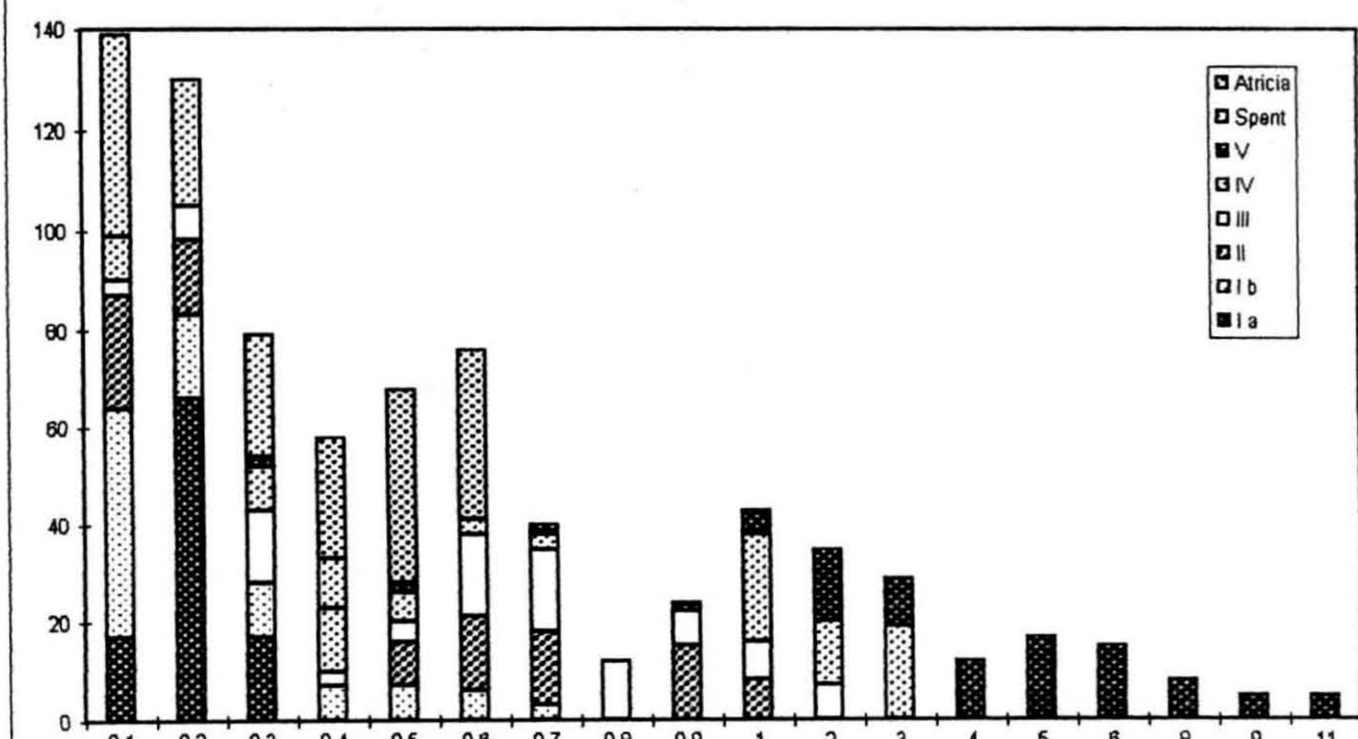
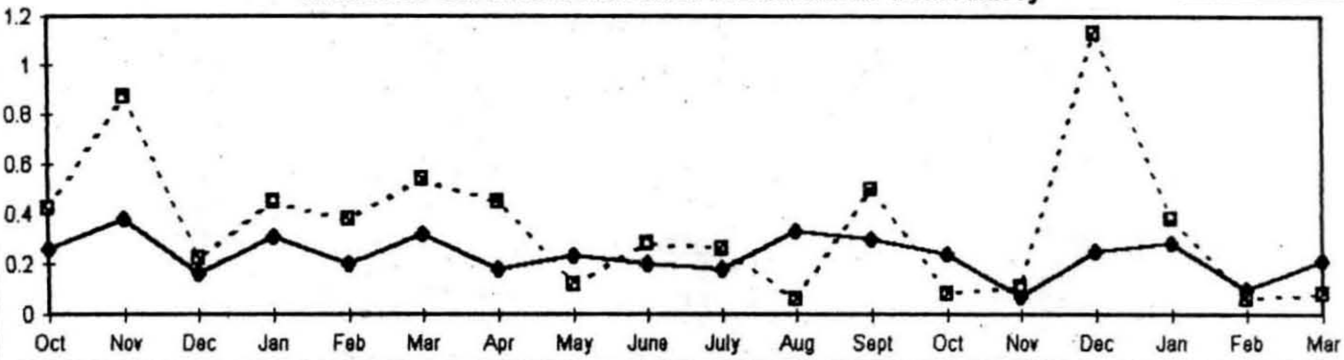
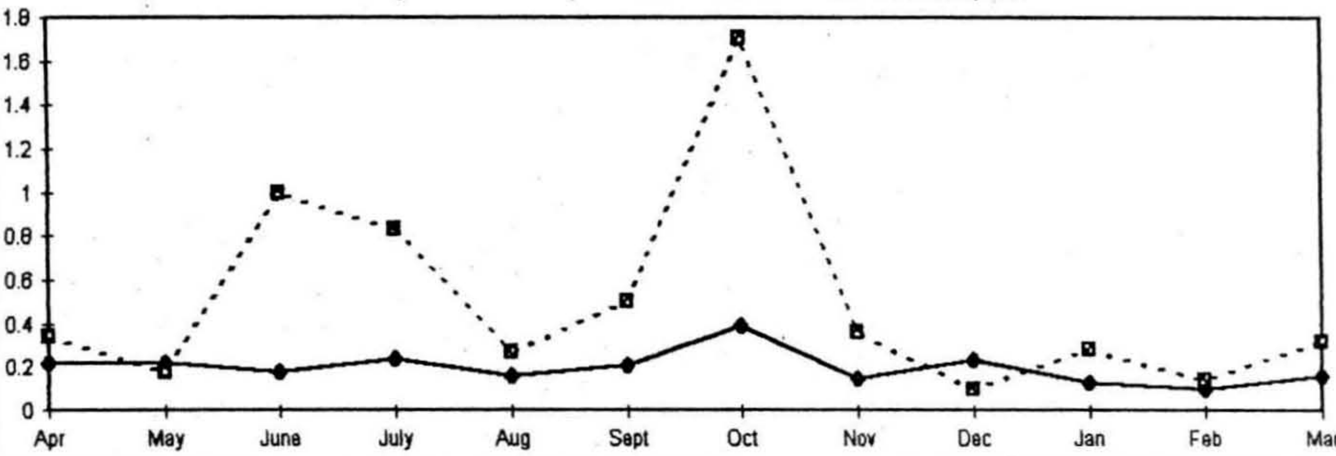


PLATE 59

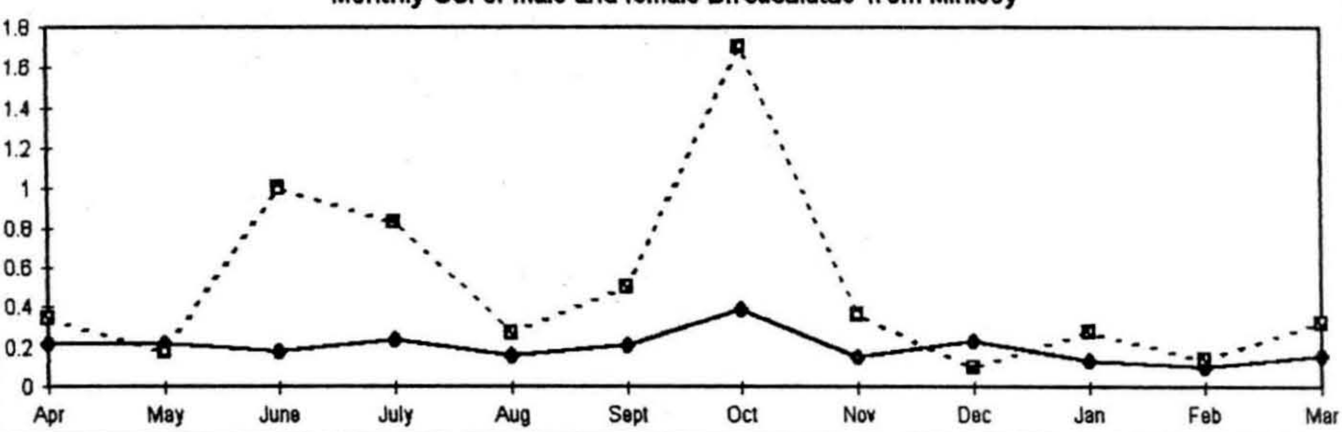
Monthwise GSI of male and female *D.trimaculatus* from Minicoy



Monthly GSI of male and female *D.trimaculatus* from Kalpeni



Monthly GSI of male and female *D.reticulatus* from Minicoy



Monthly GSI of male and female *D.reticulatus* from Kalpeni

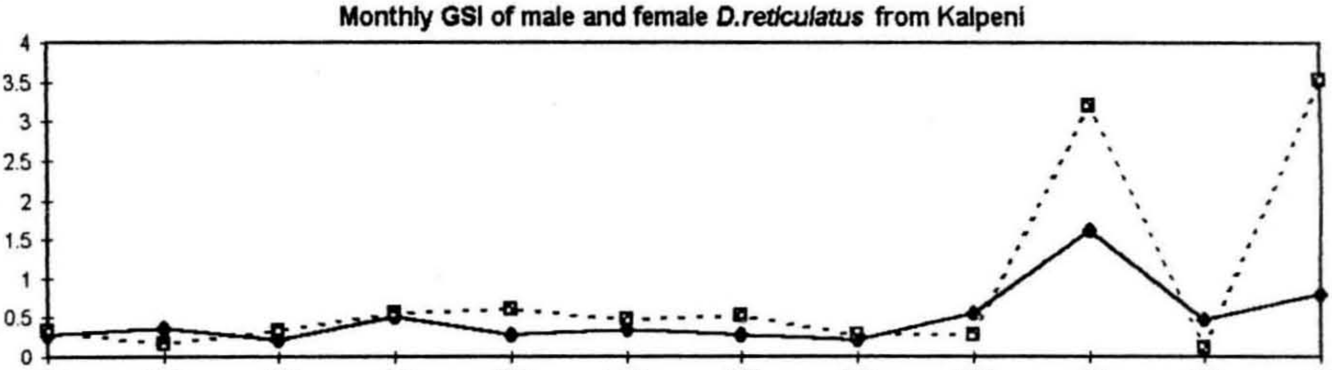


PLATE 60

Percentage occurrence of ova diameter in mm at different maturity stages in *C.auriga*

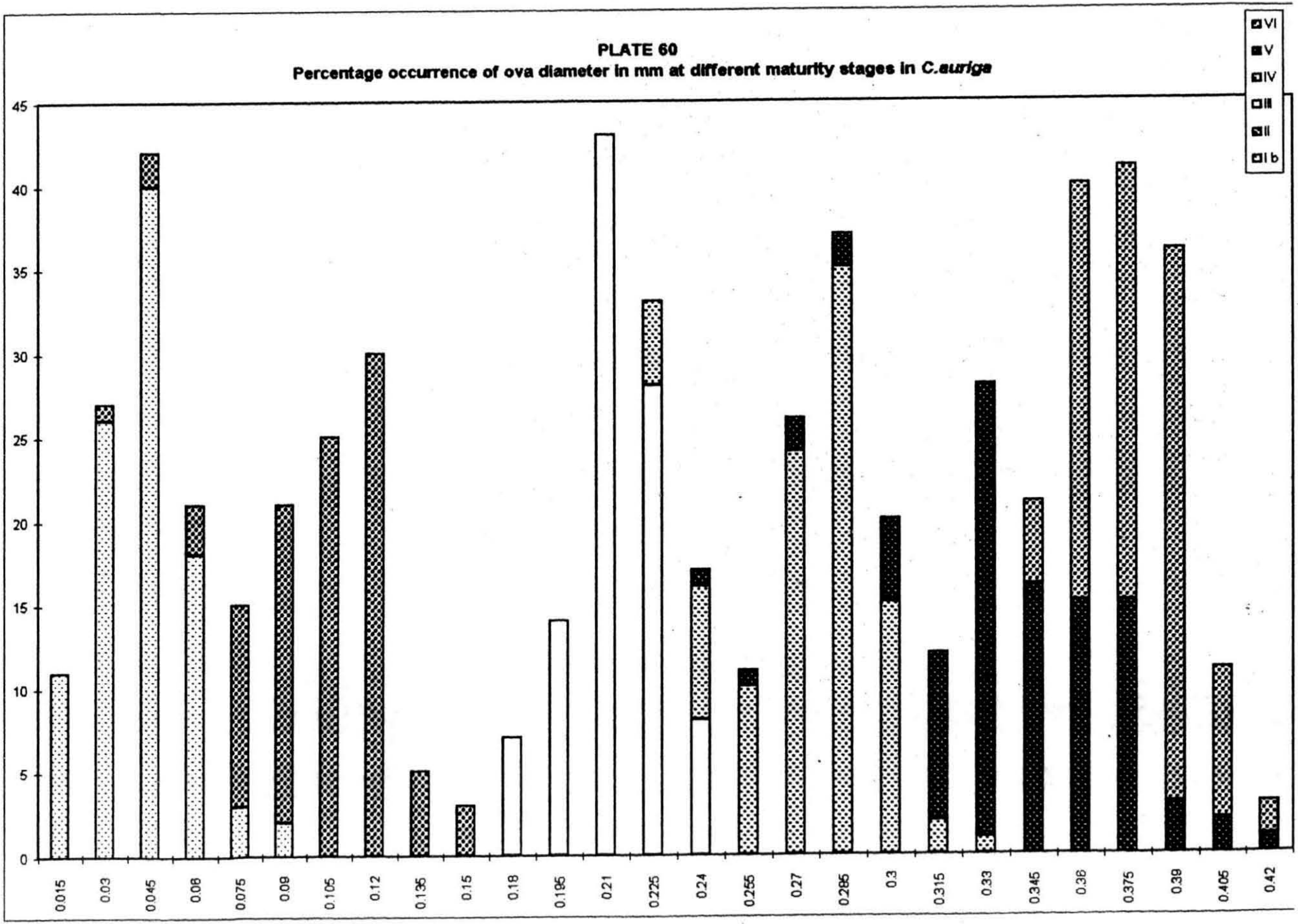
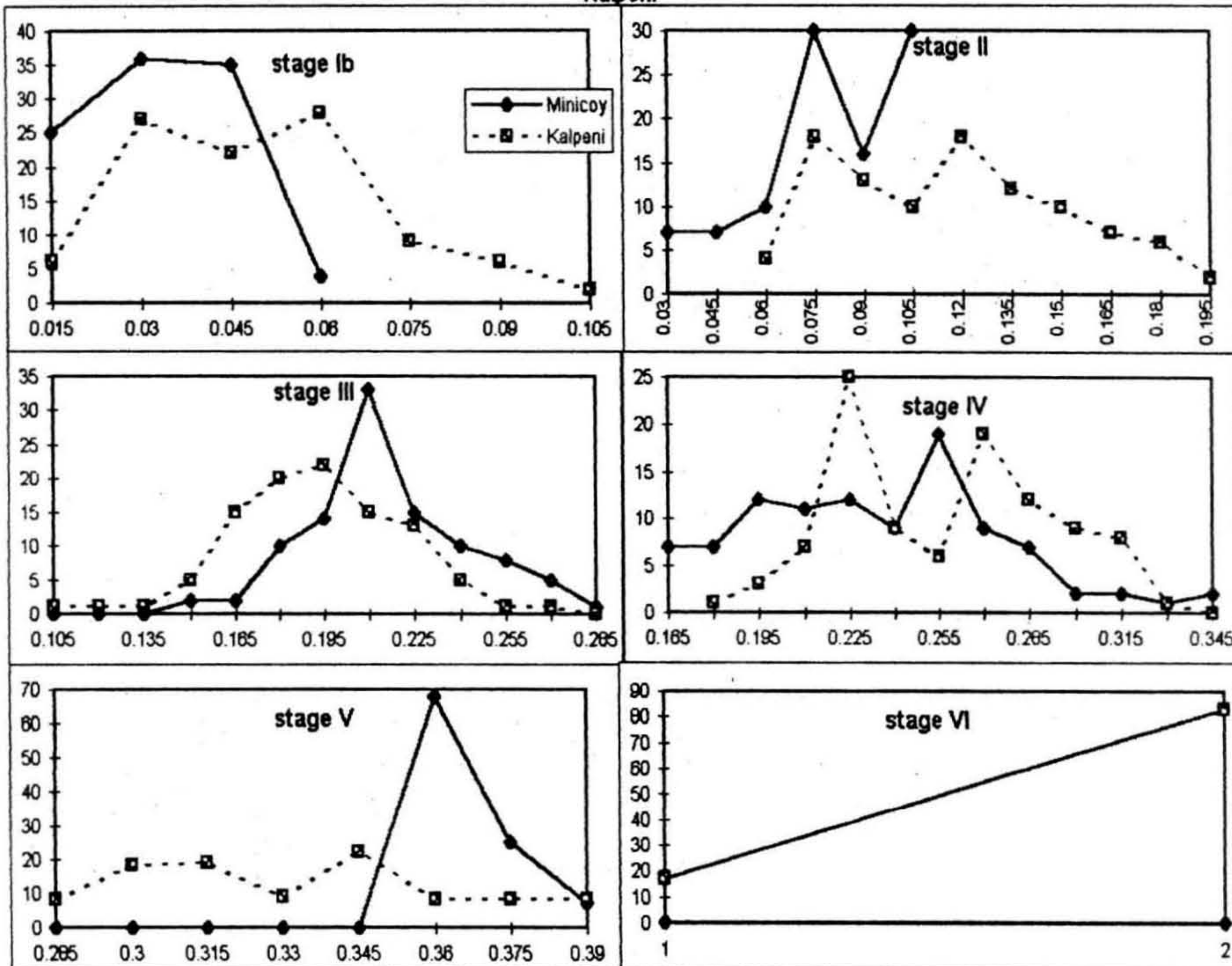


PLATE 61

Percentage occurrence of width of ova in mm at different maturity stages in *D.trimaculatus* from Minicoy and Kalpeni



Percentage occurrence of length of ova in mm at different stages in *D.trimaculatus* from Minicoy and Kalpeni

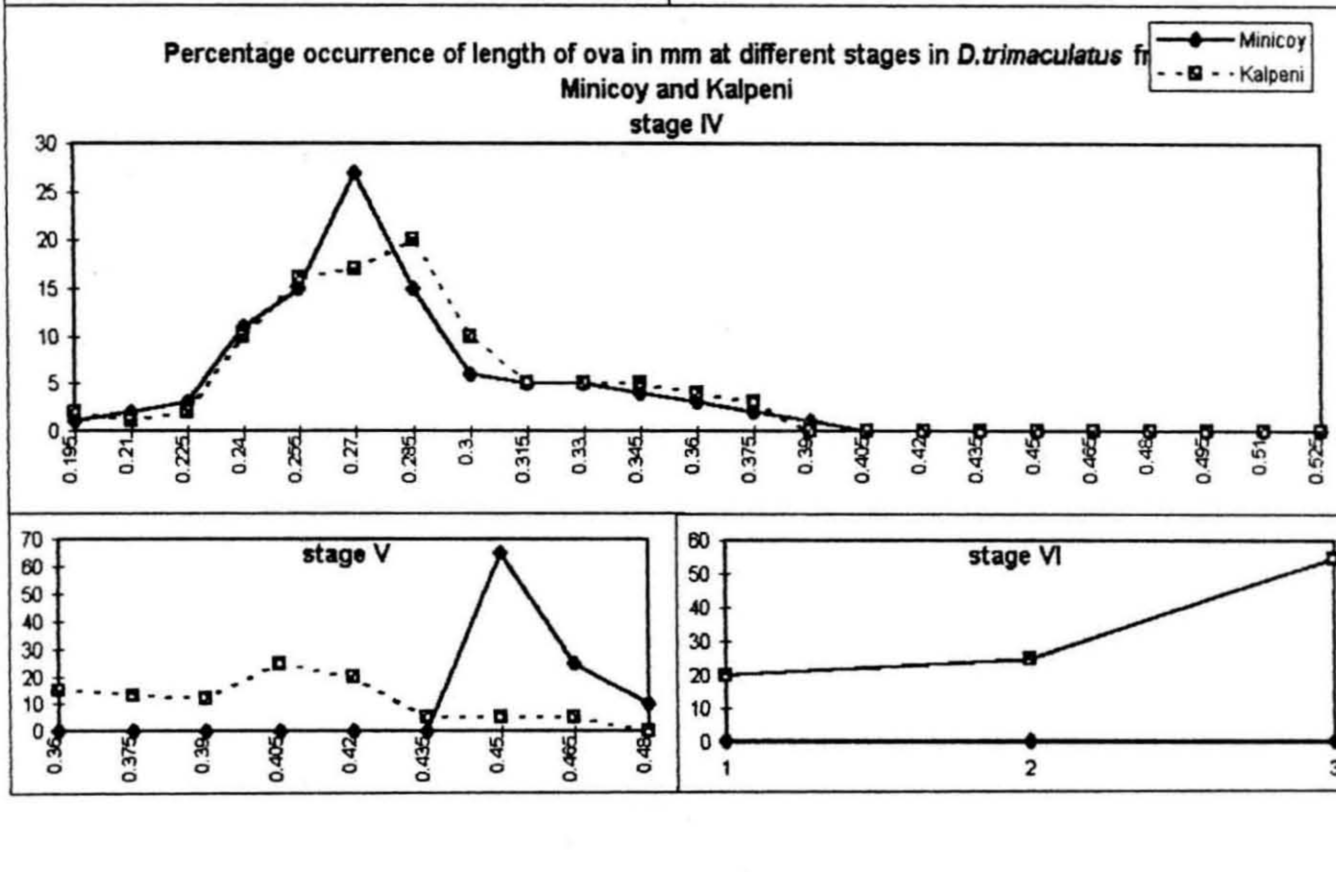
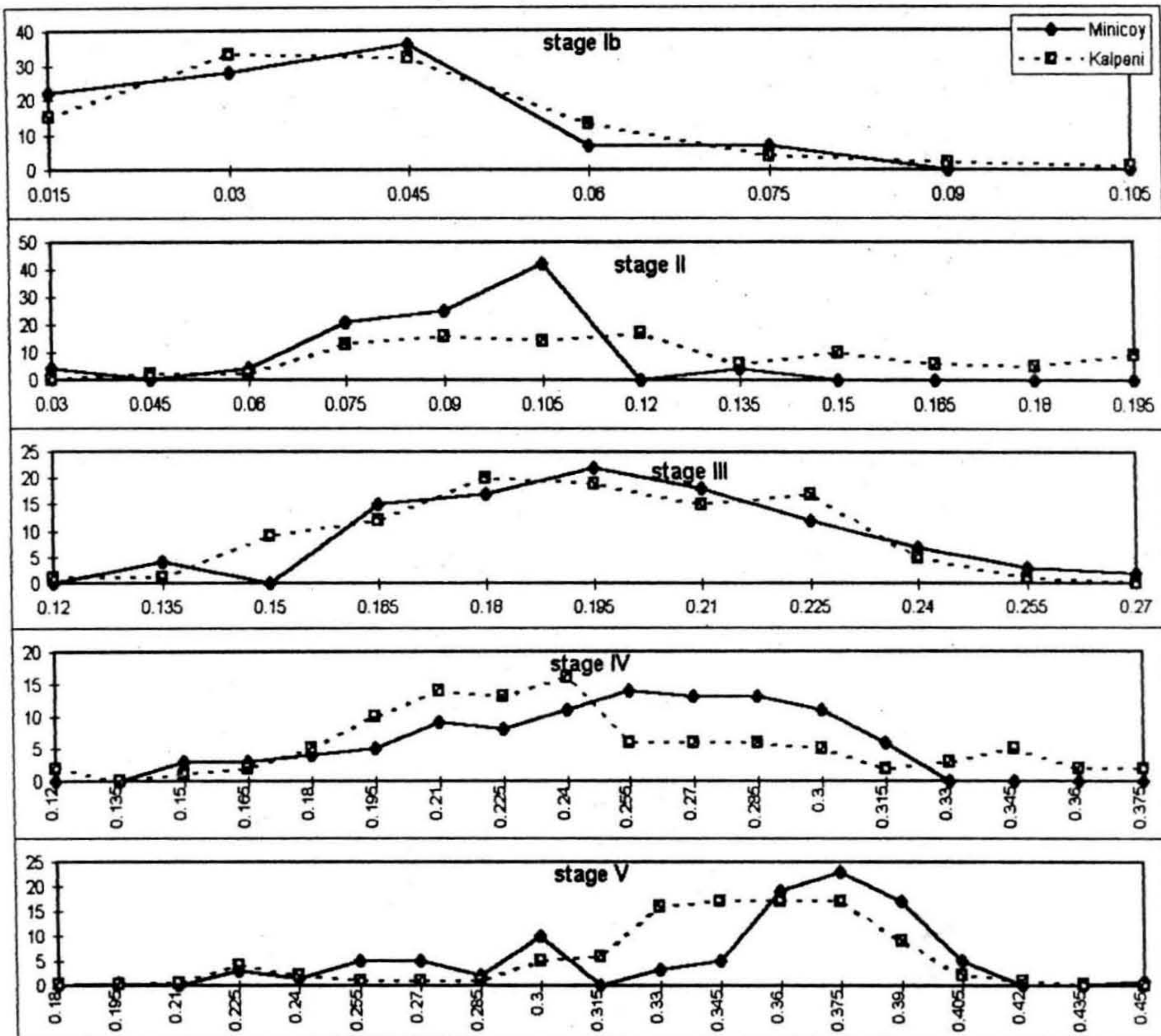
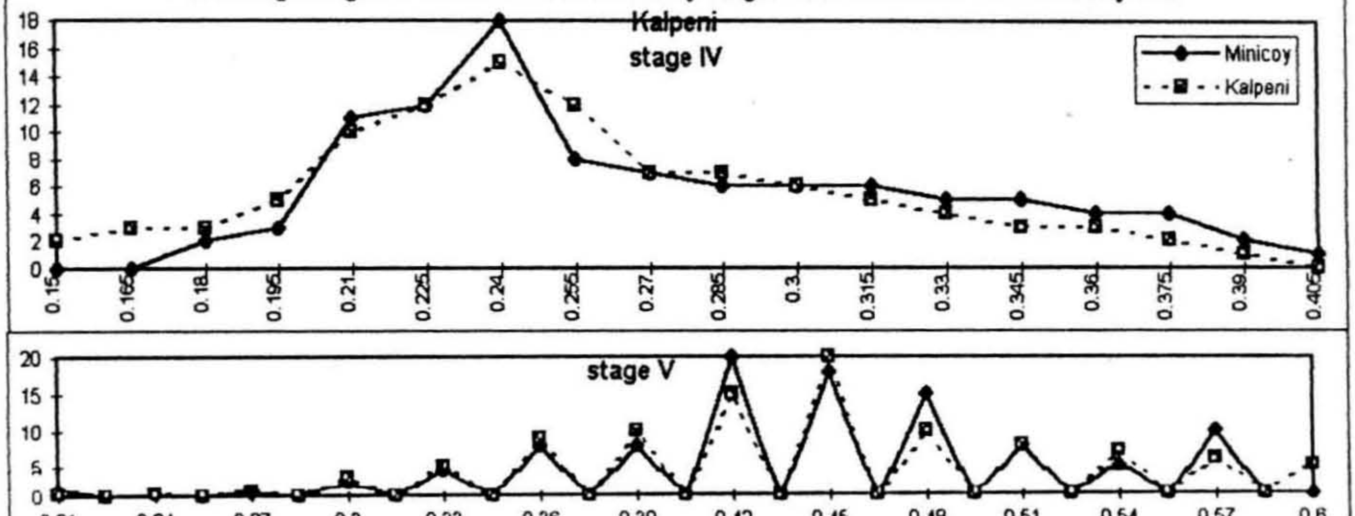


PLATE 62

Percentage width of ova at different a tages in *D.reticulatus* from Minicoy and Kalpeni



Percentage length of ova at different maturity stages of *D.reticulatus* from Minicoy and Kalpeni



SUMMARY

The ornamental fishes by their most fascinating colours have attracted the people all over the world and there is an increasing demand for these fishes to maintain them in home acquaria. The development of technology for transporting live ornamental fishes has revolutionised the ornamental fish trade. However the exploitation of ornamental fishes for export from India remains negligiable, even though vast resources of these fishes exist particularly around the Andaman and Lakshadweep Islands. So on consideration of the world wide demand and the tremendous export potential of the ornamental fishes, the present work on these fishes was undertaken to provide some basic information on the species composition, distribution and abundance, length - weight relationship, food and feeding and reproductive biology. For the study of length - weight relatioship, food and feeding habits and reproductive biology five species from family Chaetodontidae and two from family Pomacentridae were selected.

1.SPECIES COMPOSITION

A total of 169 species were collected which belong to 18 different families. Families Chaetodontidae and Pomacanthidae are exclusively ornamental fishes. Other important families in respect of aquaristic value are : Holocentridae, Pomacentridae, Labridae, Scaridae, Acanthuridae, Zanclidae, Platacidae, Cirrhitidae, Gobiidae, Lutjanidae, Apogonidae, Scorpaenidae, Balistidae, Monacanthidae, Ostracidae and Canthigasteridae.

Nine species were collected from the family Holocentridae, 17 from Chaetodontidae, 3 from Pomacanthidae, 31 from Pomacentridae, Labridae - 33, Scaridae - 11, Acanthuridae - 10, 2 each from Zanclidae, Platacidae and Cirrhitidae, Gobiidae - 10, Lutjanidae - 3, Apogonidae - 12, Scorpaenidae - 5, Balistidae - 7 and 4 each from Monacanthidae, Ostracidae and Canthigasteridae.

2. DISTRIBUTION AND ABUNDANCE

A total of 55 species were observed in the different habitats namely coral bed, reef flat area, sand bed, mixed bottom and seagrass bed. All the 55 species were present in the coral bed habitat, followed by 51 in the mixed bottom and 40 in the reef flat area. Only two *Chaetodon* species were found in the sand bed habitat and no other fishes represented in the 18 families were encountered and in the seagrass bed none of the fishes from the above 18 families were observed. Except for one species of Platacidae, the distribution and abundance of ornamental fishes was almost same in the coral bed and mixed bottom habitats. Fishes belonging to the families Apogonidae, Scaridae, Holocentridae, Cirrhitidae and Lutjanidae were not found distributed in the reef flat area. Apart from this exception the number of species in the other families remained more or less same as that of the coral bed and mixed bottom habitats. Regarding the average number of fishes in each family, more number of fishes were observed in the coral bed habitat followed by the mixed bottom habitat and among the three habitats the lowest number of fishes was encountered in the reef flat area.

Very little monthly variation was observed in the number of each species in the three habitats namely coral bed, reef flat area and mixed bottom habitat. No correlation was observed between the distribution and abundance of fishes and the hydrography and zooplankton. It was observed that there was only a narroww range in the distribution of values of temperature, DO_2, salinity, PO_4, SiO_3, NO_3, NO_2 and the volume of zooplankton in the five habitats, with a few exceptions. Eventhough the various ecological conditions were almost same in all the habitats, only neglible number of ornamental fishes were observed in the sand bed and no ornamental fishes were observed in the seagrass bed throughout the entire period of study.

The fishes showed a clear affinity towards corals either dead or alive. In the atolls of Lakshadweep it was common that the distribution and abundance of ornamental fishes depended on the distribution and abundance of corals in the lagoon. Wherever corals were available, some ornamental fishes were invariably seen associated with them.

3. LENGTH - WEIGHT RELATIONSHIP

The length - weight relationship of *Chaetodon auriga*, *C. lunula*, *C. xanthocephalus*, *C. trifasciatus*, *C. trifascialis* belonging to the family Chaetodontidae and *Dascyllus trimaculatus* and *D. reticulatus* of the family Pomacentridae was done. It was observed that the males, females and the indeterminates of all these fishes followed the linear relationship $W = aL^b$, between length and weight. Since the covariance analysis of the males and females of the above species showed significant variation in the slope and elevation except in the case of *C.lunula* from Minicoy,*C.trifasciatus* from Kalpeni and *D.reticulatus* from Minicoy, separate formulae were used for the length - weight relationship of male and female. Common formulae were derived for the length - weight relationship between male and indeterminates of *C.auriga* from Minicoy and Kalpeni, *C.lunula* from Minicoy, *C.xanthocephalus* from Minicoy, *C.trifasciatus* from Kalpeni and *D.trimaculatus* and *D.reticulatus* from Minicoy. Among the females and indeterminates, common formula was derived only for *D.trimaculatus* from Minicoy.

4. FOOD AND FEEDING HABITS

In general, most of the fishes were actively fed followed by the moderately fed fishes and the percentage of poorly fed fishes was relatively low. The food items of *C.auriga*, *C.lunula* and *C.xanthocephalus* consisted of fish scales, amphipods, euphosids, copepods, cumaceans, serpulid worms, their tentacles and brood pouch, other polychaete worms, terebellid tentacles, polychaete larvae, sipunculid worms, invertebrate eggmass, *Obelia* fragments, sea anemones, other hydroids, semidigested materials and plants materials. The plant materials include the diatom *Skeletonema costatum* and the algae, *Codium* sp., *Gracilaria acerosa* and *Hypnea valentiae*. In *C.trifasciatus* the diet consisted of coral polyps, algae and semidigested materials. Only coral polyps were observed in the stomach of *C.trifascialis*.

Eventhough the diet of chaetodons except that of *C.trifasciatus* and *C.trifascialis*, comprised a variety of animal and plant materials, only terebellid tentacles and seaanemones were the dominant items and all the others were observed in negligiable quantities. Thus in the case of *C.auriga*, *C.lunula* and *C.xanthocephalus* terebellid tentacles ranked (1) in the annual index of preponderance of the various food items and the sea anemones (2).

The various food items of *D.trimaculatus* and *D.reticulatus* were fish eggs, fish scales, bivalves, copepods, amphipods, decapods, isopods, mysids, *Lucifer* sp., ostracods, phyllosoma, zoea, cypris stage of *Balanus* sp., megalopa, other decapod larvae, serpulid brood pouch , polychaetes, polychaetae larvae, invertebrate eggmass, sea-anemones, *Obelia* fragments , siphonopheres, other hydroids, digested materials and plant materials. The plant materials comprised the diatom *Skeletonema costatum*, *Enteromorpha compressa* and the algae *Rhizoclonium* sp., *Hypnea valentiae*, *Polysiphonia* sp., *Ceraminum* sp., *Osciallatoria* sp.and *Lyngbya* sp. Among the various food items, copepods and plant materials were dominating and the other items were insignificant in their relative volumes. Copepods ranked (1) and plant materials ranked (2).

5. REPRODUCTIVE BIOLOGY

Since the chaetodontids move in pairs in the natural habitats, their sex ratio was taken as 1:1. In the case of the two pomacentrids, females outnumbered males.

The sexual differentiation in *C.auriga* occured at the size between 5 - 6.9 cms, in *C.lunula* between 6 - 6.9 cms, *C.xanthocephalus* and C.triafasciatus it was between 5 - 5.9 cms. Differentiation of male *D.trimaculatus* occured between 3 - 3.9 cms and in female *D.reticulatus* between 2 - 2.9 cms size groups in both the samples.

The size at first maturity of *C.auriga* was 13.1 cms, that of *D.trimaculatus* 6.7 cms and that of *D.reticulatus* was 3.6 cms.

All the chaetodontids and the pomacentrids were continous spawners.

The number of eggs in *C.auriga* ranged between 16885 and 87494, that of *D.trimaculatus* between 1108 and 8700 and that of *D.reticulatus* between 331 and 18346. No significant correlation was observed between fecundity and total length of fish in the case of *C.auriga* and *D.trimaculatus* from Kalpeni. Except in the case of *D.trimaculatus* from Kalpeni significant correlation was observed between fecundity and total weight of fish. In all the fishes studied, correlation between fecundity and ovary weight was found to be significant.

The maximum size of ova observed in *C.auriga* was 0.42 mm. In *D.trimaculatus*, the length of mature eggs ranged between 0.495 and 0.525 mm and the width between 0.405 and 0.42 mm. In *D.reticulatus* the length of ova ranged between 0.21 and 0.6 mm and width between 0.18 and 0.45 mm.

****

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